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The Journal of Bone and Joint Surgery

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
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October 1943

8 THE FENWAY, BOSTON, MASSACHUSETTS, U. S. A.

Vol. XXV, No. 4 *Published Quarterly* Old Series: Vol. XLI, No. 4

The Journal of Bone and Joint Surgery*

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The Journal of Bone and Joint Surgery is issued quarterly — in January, April, July, and October. The subscription price, payable in advance, is $5.00 per year in the United States; $5.25 in Canada; and $5.75 in foreign countries. Single copies $1.50.

Entered as second-class matter August 1, 1921, at the Post Office, Boston, Mass., under the act of March 3, 1879, and additional entry at the Post Office, Concord, N. H., authorized May 18, 1932. Publication office, 10 Ferry St., Concord, N. H. Editorial and business offices, 8 The Fenway, Boston, Mass. Accepted at the special rate of postage provided for in the act of February 28, 1925, Paragraph 4, Section 412, Postal Laws and Regulations; authorized April 21, 1933.

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VOL. XXV, NO. 4 OCTOBER, 1943 Old Series Vol. XLI, No. 4

The Journal of
Bone and Joint Surgery

SUBASTRAGALAR ARTHRODESIS IN FRACTURES OF THE OS CALCIS

BY W. E. GALLIE, M.D., TORONTO, ONTARIO, CANADA

The results of the treatment of those fractures of the os calcis which involve the astragalocalcaneal (talocalcaneal) joint are often so poor that arthrodesis becomes a necessity. The indications are:

1. Pain through the joint with walking and standing;
2. Acute twinges of pain when the heel strikes an uneven surface;
3. Marked limitation in the ordinary movements of the joint;
4. Definite roentgenographic evidence of irregularity in the articulating surfaces.

The operation, unfortunately, is difficult, and. from the standpoint of magnitude and risk, quite out of proportion to the injury. It involves the removal of not only all the articular cartilage of the subastragalar joint, but also that of the mid-tarsal joint, and it is attended by much difficulty in fitting all the denuded surfaces together, and by considerable uncertainty about the fusion.

The plan here offered is designed to arthrodese the subastragalar joint by a minor operation, without further reducing the height of the foot, and without interfering with the mid-tarsal joint. With the patient lying prone, an incision, two and one-half inches long, is made along the lateral side of the tendo achillis, down to the os calcis. This is deepened through the superficial and deep fascia, through the transverse intermuscular septum which separates the soleus and gastrocnemius from the flexors of the toes, and through the fat which fills the space between the posterior end of the subastragalar joint and the sheath of the tendo achillis. The exposure is improved if some of this fat is excised. With the help of a pair of Lahey retractors, the posterior aspect of the lower end of the tibia, the belly of the flexor hallucis longus, the ligaments of the ankle joint and the subastragalar joint are now brought into view, and the position of the sub-

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 7, 1943.

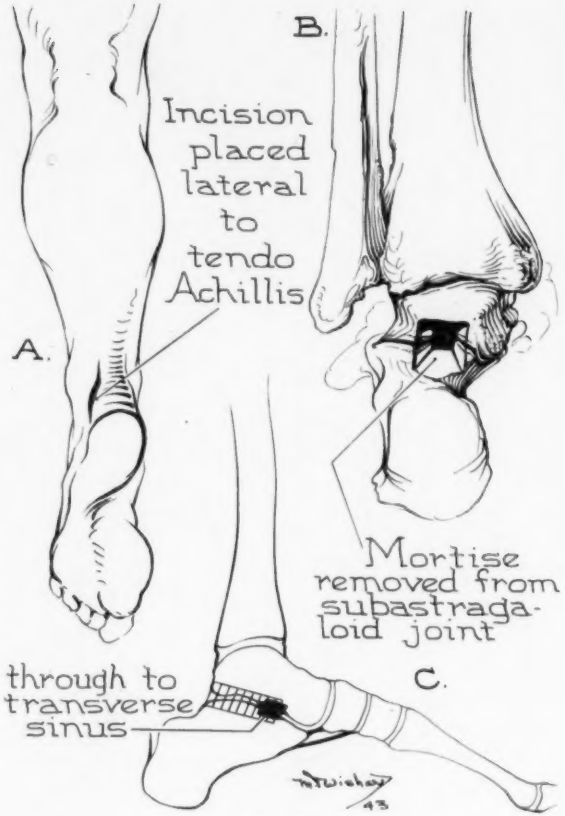

FIG. 1

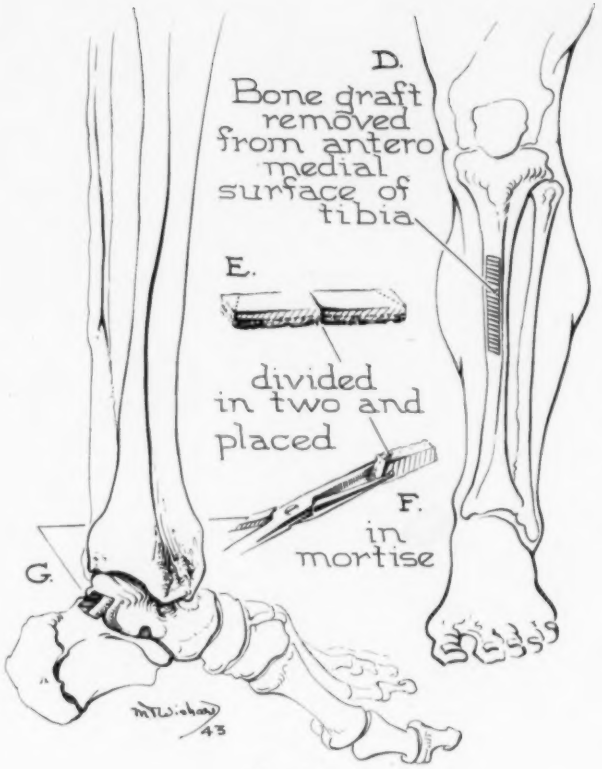

FIG. 2

(See page 733 for legends)

FIG. 1

Diagram illustrating arthrodesis of subastragalar joint.
A: Incision lateral to tendo achillis.
B: View of skeleton from the back, showing the mortise cut in the astragalus and os calcis.
C: Lateral view showing mortise extending through to the transverse sinus of the foot.

FIG. 2

D: A graft two and one-half inches long has been removed from the medial surface of the tibia.
E: The graft has been bisected and bevelled as indicated by the dotted lines.
F: The graft is ready for insertion into the mortise.
G: One graft has been tapped into position in the mortise, and the second is ready for insertion, completing the operation.

astragalar joint is demonstrated by rocking the os calcis sideways. The capsule and synovial membrane of this joint are then incised transversely, and the articular cartilages are exposed. When the general direction of the articulating surfaces has been demonstrated by a thin osteotome slipped deeply into the joint, a mortise is cut in the os calcis and astragalus, slightly over one-quarter of an inch deep in each bone, a little over one-half of an inch wide, and extending forward to the transverse sinus of the foot. If this has been cut cleanly, the line of the articulating surfaces can be seen in the lateral walls of the mortise (Fig. 1). The knee is now flexed, and a graft, two and one-half inches long and a little over one-half of an inch wide, is removed from the medial face of the tibia. This is divided into two equal parts and one end of each is bevelled, as shown in the diagram (Fig. 2). Some bone chips and slivers are packed into the depths of the mortise, and the two bone grafts are fitted into it in such a way that they are standing on their edges, back to back, with their cancellous surfaces pressing tightly against the lateral walls. If the grafts have been cut to fit the mortise accurately, and have been tapped lightly home, it can often be demonstrated that all motion in the subastragalar joint has been eliminated. The wounds are now closed, and a plaster is applied from toes to knee, with the foot at a right angle.

It should be noticed that no attempt has been made in this operation to change the relation of the astragalus to the os calcis, or to correct any deformity of the foot. If such were necessary, some different operation would be required. Fortunately the deformity in most cases is not great; in 90 per cent. it is a mild valgus of the heel which is of little consequence. In the occasional case, however, in which the primary deformity is one of varus of the heel, this operation should not be done, as it produces an ankylosis in such a position that undue weight comes on the head of the fifth metatarsal with a resulting painful callosity there.

This operation is followed by very little reaction or discomfort. The patient leaves the hospital on crutches in four or five days, and returns for removal of the plaster in three months. A walking plaster is then applied and is worn for six weeks, after which time he uses ordinary shoes. In some instances, particularly in private patients, he returns to business immediately with very little complaint, but in most compensation cases

FIG. 3-A

FIG. 3-B

FIG. 3-A: Roentgenogram showing old fracture of the os calcis, involving the subastragalar joint in the sagittal plane, with half of the articular surface crushed down into the body of the bone.

FIG. 3-B: Roentgenogram taken three months after operation, showing the grafts uniting to the walls of the mortise.

a period of from four to six weeks of convalescence must be passed before he returns to light work. Soon after that, however, he forgets all about his foot and gets back to railway-section work, braking on the railroad, steel construction, or whatever it may be, without any disability other than the loss of the lateral movement of the heel (Figs. 3-A, 3-B, and 3-C).

FIG. 2-C

Roentgenogram taken a year after the operation, showing solid arthrodesis.

The author's experience with this method extends over six years, and is based upon operations on fifty patients. In addition, intimate colleagues have reported nearly fifty more, so that it is possible to assess the results. In all, there has been primary union; and in all, except half a dozen, immediate solid ankylosis. In several in whom the grafts were too loose in the mortise, the fusion was delayed and the convalescence prolonged by several months. In one, fusion failed completely, because the mortise in the astragalus was too shallow. A second operation was necessary to remedy the defect.

It would seem, therefore, that this plan of treatment substitutes, for a difficult, somewhat mutilating and uncertain operation, a simple and safe procedure, requiring not more than thirty minutes of anaesthesia, and one from which a quick arthrodesis and a complete relief from pain can be confidently expected.

DISCUSSION

DR. E. BISHOP MUMFORD, INDIANAPOLIS, INDIANA: I wish to discuss Dr. Gallie's paper for several reasons. My experience includes ninety-three cases, extending over a number of years. I remember that several years ago I asked Dr. Speed what he considered a good result, because my results were not satisfactory. He said that if a patient had only 20 per cent. disability he thought it was fine. In our experience, we have found that in a great many of the cases the foot cannot be restored to normal, and the old cases have been very disappointing. I have done about eighteen so-called triple arthrodeses, and I do not think any of them have been very successful. I mean by that statement that I have not been able to get the men back to work. With that in mind, I heard Dr. Gallie's paper in Toronto two years ago, and I thought there might be a solution. In the first case I did, the man who had been away from work for eighteen months, went

back to work at the end of four months with a perfectly painless heel. I thought the solution was there, and that it was a very simple operation to do. Since that time I have done fourteen more of these cases. Some of them unfortunately had been complicated, being bilateral cases, one with a fracture of the astragalus on the other foot and one with a compound fracture of the ankle on the other foot, thus making it rather difficult to evaluate the end result in the heel which had been operated upon. In these fourteen cases there have been 65 per cent. of what we considered good results. The others have been cases in which there has been considerable relief of pain, in that the patients were able to get about better than before but not able to do heavy work. Several days ago I talked to one patient who said he could carry on his work which necessitated getting in and out of the car, but he could not do heavy work, because he had too much pain at the end of the day.

This is the experience I have had with fourteen cases, and I thought it might be interesting. It comes nearer to solving the problem of treatment of old fractures than anything we have today. It seems to me that, if we could prove this to be a good operation, we should not wait too long before applying it to fresh cases of fracture of the os calcis.

Dr. Harold R. Conn, Akron, Ohio: Dr. Gallie is to be congratulated on his very ingenious method of fixing or fusing the subastragalar joint. However, his operation does not correct severe lateral expansions of the tuberosity, the pressure on the peroneal tendons, or the disruption of the astragaloscaphoid and the calcaneocuboid joints, present in the more severe types of fractures.

Eight years ago when I suggested triple fusions for severe fractures of the os calcis, I received a number of letters from British and Australian surgeons who stated that my title was confusing, since what I really meant was a double arthrodesis. They said in part, "If we fuse the subastragalar joint, we consider it imperative to fuse the astragaloscaphoid joint, for the two, while separate synovial compartments, are functionally reciprocal in their action". Gwilym Davis, thirty years ago, called attention to this necessity of fusing the astragaloscaphoid joint whenever, for the purpose of stabilization, it was necessary to fuse the subastragalar joint. My contention was and is that this same functional relation is present between the astragaloscaphoid and the calcaneocuboid joints. Almost all anatomists have recognized this reciprocal action between these three articulations.

A careful study of the roentgenograms of a series of severely fractured ossa calcum will reveal the fact that, not alone are the subastragalar joints disrupted, but likewise the astragaloscaphoid and calcaneocuboid articulations.

I should like to repeat what I have previously said that fusing the subastragalar joint alone in anything except the simplest lesions leaves the head and the neck of the astragalus projecting forward unsupported, and produces a constant weight-bearing lever operating against the fusion.

Although a triple fusion is said to be a difficult operation, the technique may be simplified by a subcortical exposure of all the joints through one incision, which permits an easy reconstruction of the whole region of the os calcis and its reciprocal joints.

The failures following triple arthrodesis have almost universally been found to be the result of incomplete fusion or improper realignment of the bones.

I still hold with our British and Australian friends and the anatomists that it is as illogical to fuse the subastragalar joint only as it would be to fuse one-half of the knee joint.

Dr. W. E. Gallie, Toronto, Canada (closing): I am very grateful for the discussion. The only comment I have to make is that I agree with the speaker who said that this operation is simple enough and so certain in its results that it might very well be applied in the early cases. Dr. Harris read a paper not long ago, in which he demonstrated a method of reducing fresh fractures of the os calcis with three pins and traction and then putting the foot in a plaster-of-Paris bandage. His results were very successful.

INTERNAL AND EXTERNAL FIXATION OF HIGH OSTEOTOMIES OF THE FEMUR

BY J. ALBERT KEY, M.D., ST. LOUIS, MISSOURI

From the Department of Surgery of the Washington University School of Medicine, St. Louis.

A high osteotomy of the femur is not an ideal procedure, because it does not give a normal hip; but it is an operation which not infrequently can be used to solve a difficult problem in a satisfactory manner. In the author's experience, it is most often indicated in the treatment of hypertrophic arthritis of the hip (malum coxae senilis) and fractures of the neck of the femur which have not united and in which the head is living. The author has not used this operation in the presence of a dead head, and he does not know whether or not it would yield a useful hip in such a case. Formerly the two-pin method of fixation, as advocated by Gaenslen, and Schumm, was used, but this necessitated a large spica cast in addition to the pins. Then McMurray's method was found satisfactory, but the prolonged fixation in a large plaster cast was a serious objection in elderly patients, a considerable percentage of whom were obese.

In the summer of 1940, one such patient developed a non-union after the author had performed a McMurray osteotomy (Fig. 1-A). This patient was a poor operative risk, and had had a stormy postoperative course in the spica cast after the osteotomy. The hip was not only unstable but painful, and he could not use crutches well on account of his obesity and a flail elbow on the opposite side.

Not long before this, a screw had been used to fix the fragments after a similar osteotomy for an old septic hip with absorption of the head and an adduction deformity (Figs. 2-A and 2-B). A spica cast had been used in this case, but it was thought that fixation of both feet in plaster boots with a board between them to maintain abduction and stability in rotation would be sufficient if the fragments could be fixed by one or two screws at the site of the osteotomy. This would enable the patient to sit up in bed as soon as he recovered from the anaesthetic, to move about in bed with the aid of an overhead trapeze, and to be turned on his side.

At the operation a well-developed pseudarthrosis was found between the fragments. The ends of the fragments were excised and the proximal fragment was remodeled to leave a projection of the lateral cortex to fit over the lateral cortex of the distal fragment. Then the limb was abducted, and the bone ends were pushed together and fixed with two screws (Fig. 1-B). The limbs were then fixed in moderate abduction with plaster boots fastened to a board about thirty inches long. The fragments united promptly.

The result was so satisfactory that, during the past two and one-half

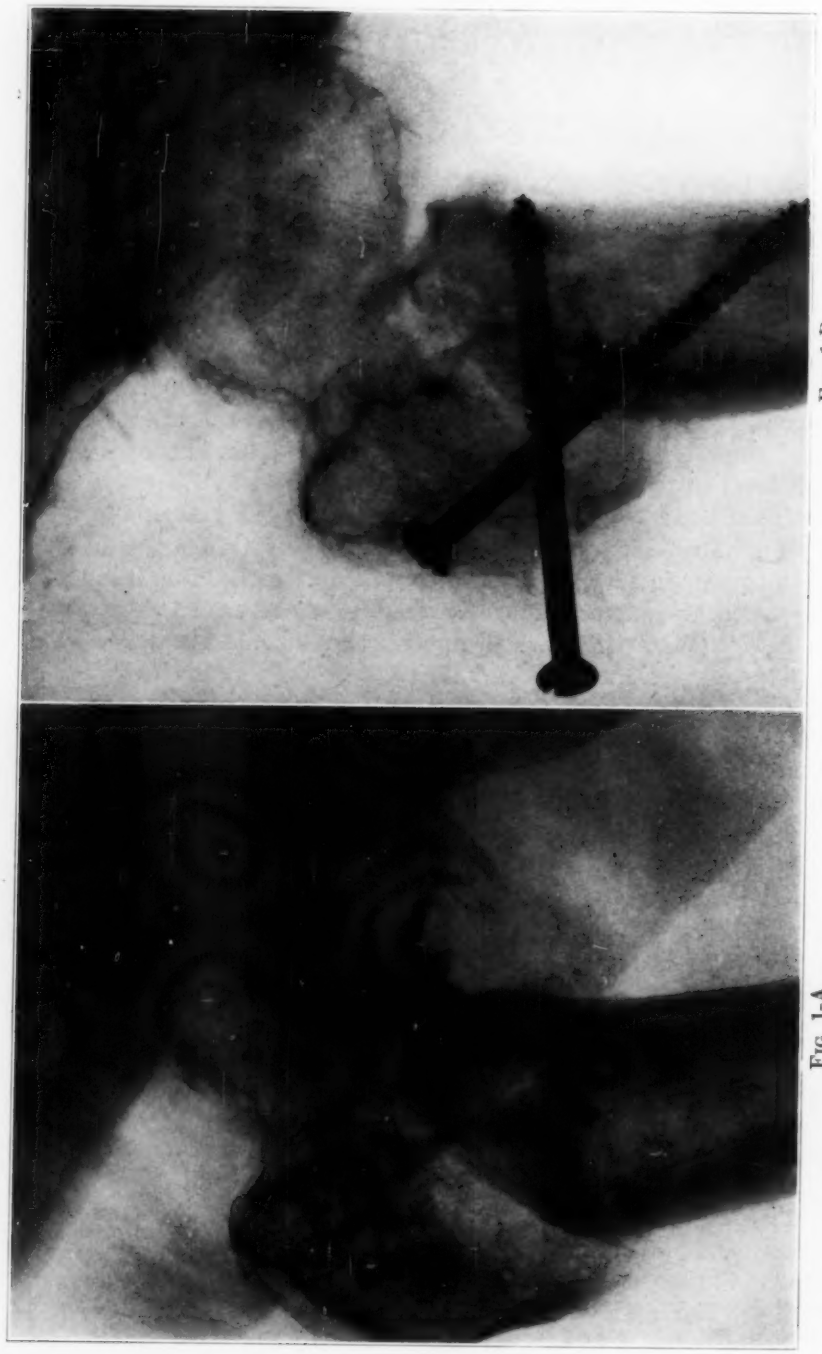

FIG. 1-B

FIG. 1-A

Fig. 1-A: A non-union after a McMurray osteotomy.
Fig. 1-B: At second operation fragments were fixed with two screws. The feet were immobilized for four weeks in plaster boots fixed to a board. The horizontal screw became loose and was removed after union was firm.

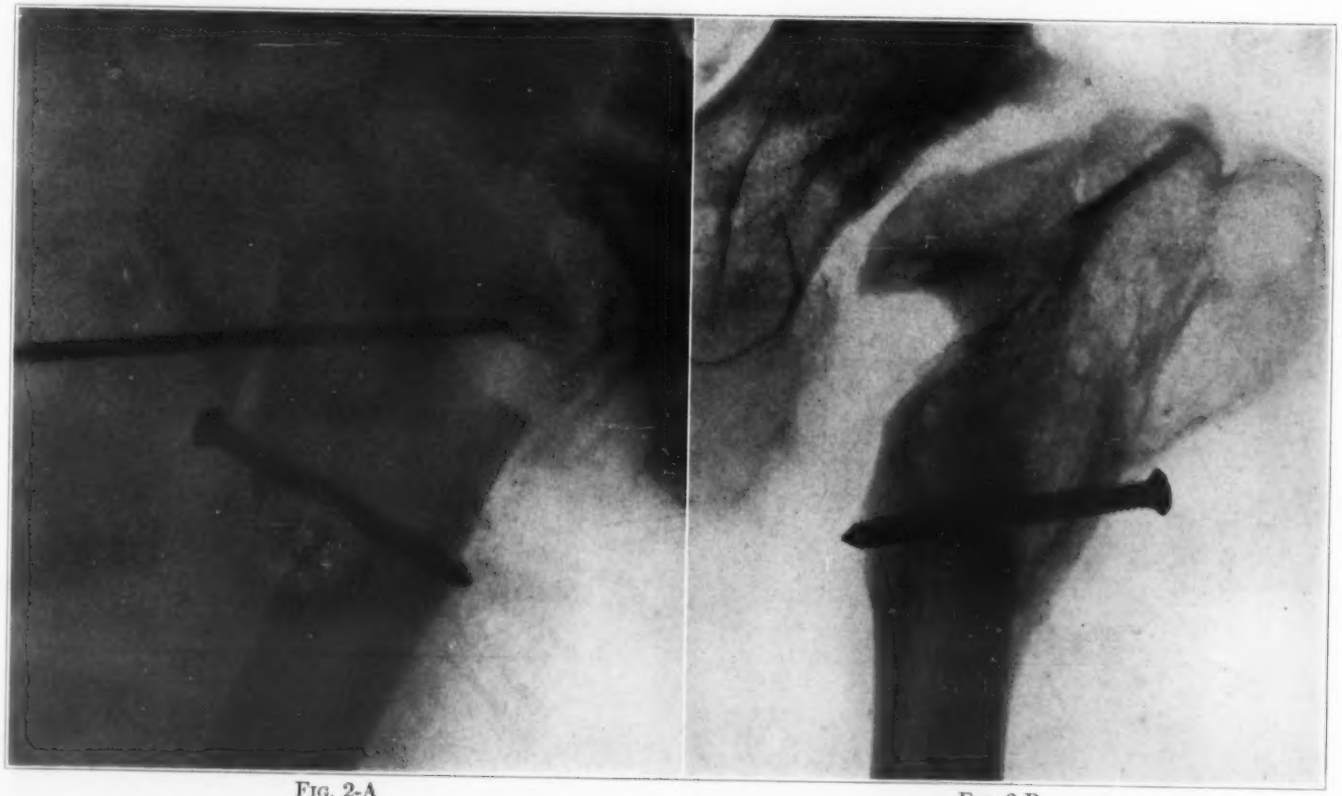

FIG. 2-A

FIG. 2-B

Fig. 2-A: Oblique osteotomy for an old septic hip. A screw and a plaster spica were used for fixation. A long pin was used to hold the transplanted trochanter down.

Fig. 2-B: The long pin which held the transplanted trochanter down was pulled out at the end of four weeks.

years, the author has not used a plaster spica for fixation after a high osteotomy of the femur.

OPERATIVE TECHNIQUE

The patient lies on his back on an ordinary operating table, and is so draped that the extremity can be manipulated. A lateral incision is begun opposite the tip of the trochanter and is extended downward for six or eight inches, the length varying with the thickness of the tissues over the side of the femur. After the deep fascia has been incised, a periosteal elevator is used to cut across and free the proximal portion of the origin of the vastus lateralis muscle from the lateral and anterior surfaces of the femur below the trochanter. Then the limb is externally rotated, and two heavy blunt dissectors are pushed down on the medial surface of the femur. One lies between the lesser trochanter and the neck of the femur, and the other lies distal to the lesser trochanter. These serve as retractors and landmarks, and the position of the lesser trochanter is verified with the operator's finger.

After the surgeon is well oriented as to the position of the lower border of the neck of the femur and the lesser trochanter, the course of the osteotomy is decided upon and its course is outlined on the anterior surface of the femur with an osteotome or a series of small drill holes. In the McMurray osteotomy this begins about one-half of an inch below the base of the greater trochanter and emerges on the medial surface just above or through the upper part of the lesser trochanter. Care is taken not to include a spur of the dense cortical bone of the medial cortex in the lower fragment. Some surgeons drive a wide osteotome directly through the bone from without inward and upward. Since there is danger of splitting the bone or cracking off part of the lower border of the neck with the distal fragment, the author uses a series of small thin osteotomes to cut the bone more slowly and carefully, dividing the lateral, anterior, medial, and posterior cortices in the order mentioned.

If it is desired to include a tongue of cortex on the proximal fragment, three drill holes are made before the osteotomy is begun. These form a triangle about one-half of an inch on each side, just above the line of the osteotomy. The holes are made with a drill three-sixteenths of an inch in diameter, are about one-half of an inch apart, and extend entirely through the bone anteroposteriorly. The base of the triangle is formed by the line of the osteotomy, and, when the drill holes are connected by cutting out the intervening bone, a tongue of the lateral cortex is left. This increases the shortening slightly, but the tongue of cortex on the proximal fragment permits the use of a small screw between this and the lateral cortex of the distal fragment; this increases the stability of the internal fixation.

When the osteotomy is complete, the limb is adducted to open the gap between the two fragments. A broad osteotome or elevator is inserted in the gap and the proximal end of the distal fragment is levered inward as

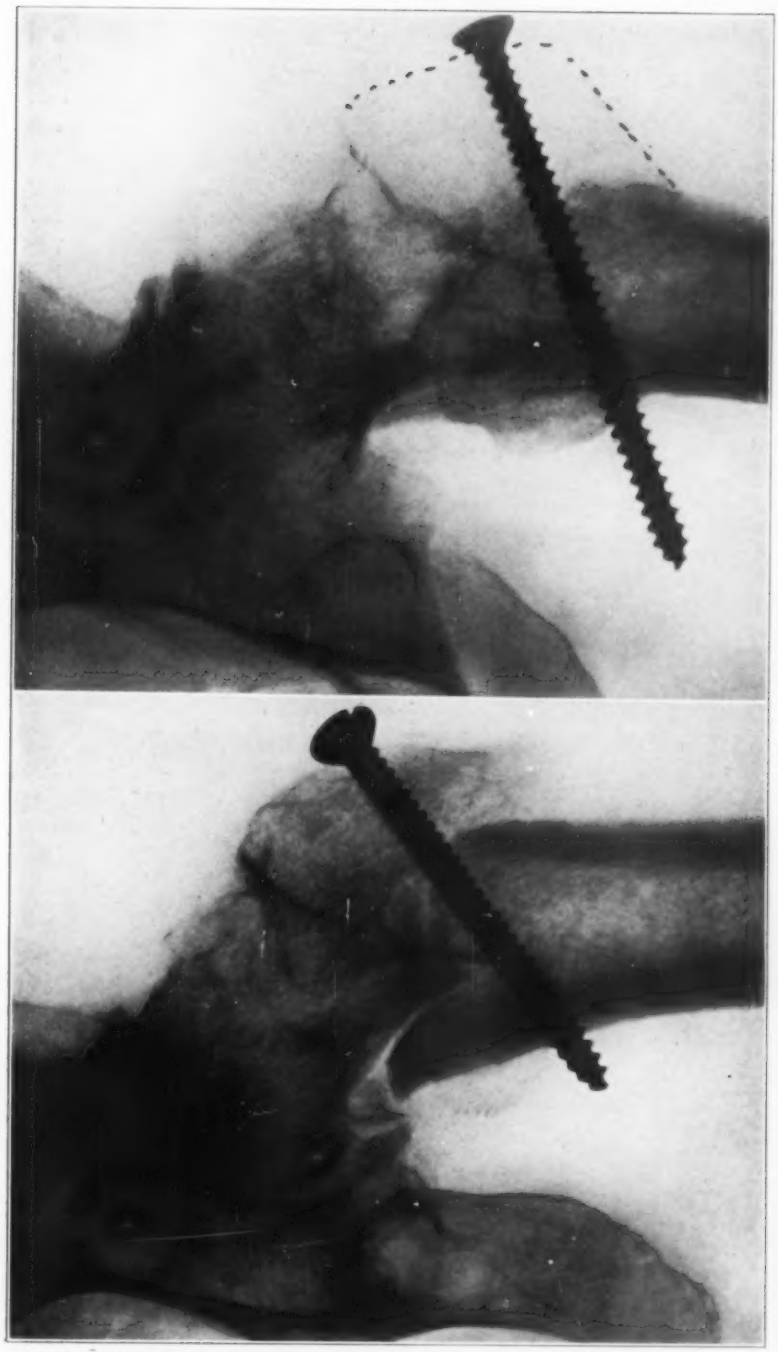

FIG. 3-A

FIG. 3-B

Fig. 3-A: An osteotomy fixed with a single large screw. This patient and the one whose fracture is shown in 3-B were immobilized in plaster boots fixed to a board.

Fig. 3-B: Another osteotomy fixed with a single large screw. This screw was later removed because it projected too far on the inner side, although it caused no symptoms.

FIG. 4-A

Fracture of the neck of the femur of five months' duration.

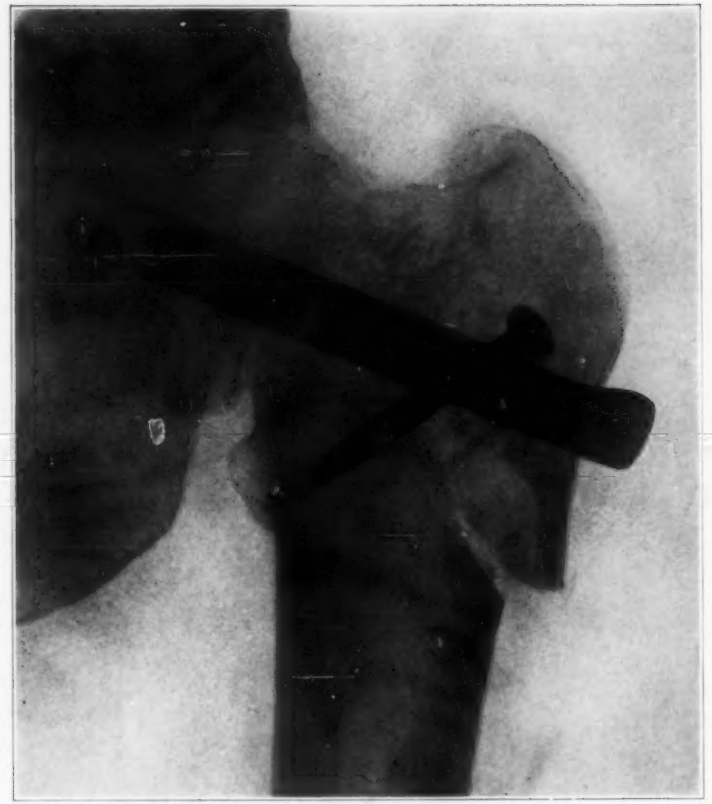

FIG. 4-B

The nail has been replaced in the correct position and the osteotomy has been fixed by one large screw. No postoperative fixation was used. There was some loss of abduction.

the limb is abducted. The distal fragment slips upward and inward beneath the neck of the femur. The limb is then manipulated until the surgeon is satisfied with the position, and is held in this position while a drill is passed downward and inward from the lateral surface of the trochanter into the medial cortex of the distal fragment. The limb is held carefully while the drill point is removed and a large screw is driven in to fasten the two fragments together (Figs. 3-A and 3-B). A second smaller screw may be inserted below this if more stability is desired. The wound is then closed.

If the operation is done for a recent non-union of the neck of the femur, a Smith-Petersen nail may be used to fix the fracture. The nail is first driven home and then the osteotomy is done. The nail may be driven in blindly, but its position must be controlled by the roentgenogram. In a man seventy-eight years old, the preoperative roentgenogram showed the fragments in good position. In order to avoid prolonging the operation, the nail was driven in and then the osteotomy was performed. The nail merely caught the lateral cortex of the head. Strangely enough the result is satisfactory. The procedure now followed by the author is to open the hip joint, reduce and nail the fracture under direct vision, as advocated by Cubbins, Callahan, and Scuderi, and then to perform the osteotomy (Figs. 4-A and 4-B). In some cases no nail is used.

When the nail is used, the large screw used to fix the fragments after the osteotomy must be directed backward as well as downward and inward in order to miss the nail.

Postoperative Fixation

Plaster boots are applied to each extremity, and these are fixed with a plaster bandage to a board to control rotation and maintain about thirty degrees of abduction. These are worn from two to four weeks. The patient can sit up in bed or be turned on the side or face. At the end of four weeks or less the casts are removed, and the patient is permitted to get up on crutches, but he is cautioned not to bear too much weight on the leg. In some cases no external fixation has been used, but these patients have been quite uncomfortable during the first few days after the operation and have lost some abduction (Fig. 4-B). Consequently, the abduction plaster boots are advised for at least two weeks.

COMMENT

When this method of fixing the fragments is compared with the blade plate introduced by Blount, it is obvious that the fixation is not so firm as that secured by Blount's method, nor is the angle of abduction controlled as exactly. On the other hand, all cases have united promptly, and the degree of fixation has been sufficient to make the patients comfortable after the operation. With regard to exact control of the angle of abduction, the author is not sure that this is very important. As a matter of fact, he is not able to decide just what angle will work best in a given patient.

The inward displacement seems to be more important, especially in the McMurray type of osteotomy. In the subtrochanteric operation, the angle could be controlled by altering the height of the triangle removed from the proximal fragment and placing the medial angle of the triangle near the medial cortex. This operation also necessitates about two weeks longer in bed than does Blount's method.

The operation has the advantage that no roentgenographic control or special equipment is necessary. Also, it seems to the author to be a less formidable procedure. As will be seen from the illustrations, no two cases were done exactly alike, and in most instances the right size screw was not used; yet the results have all been satisfactory. There should be available a series of heavy wood-type screws of non-corrosive metal from two to three inches in length, and also the usual small screws. In two patients after union was solid, one screw was removed because it became loose (Fig. 1-B), and another because it projected too far on the inner side of the femur (Fig. 3-B). The other screws and nails are still in place.

About a year ago Dr. R. N. Hatt and the author were discussing high osteotomies of the femur and Dr. Hatt said that he had used a method similar to that described here for the fixation of the fragments. It was suggested that he send the author his roentgenograms and that the method be published jointly, but he has now gone into the Service. No originality is claimed for the method, as Hatt has used it as probably have others who wish to avoid plaster spicas in elderly patients and have not the equipment, or energy, or the mechanical genius, to devise such a plate as Blount uses.

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SPASTIC PARALYSIS AND ALLIED DISORDERS *

BY H. R. MCCARROLL, M.D., AND JOHN R. SCHWARTZMANN, M.D.,
ST. LOUIS, MISSOURI

From the Shriners' Hospital for Crippled Children and the Department of Surgery, Washington University, St. Louis

The importance of spastic paralysis, and the allied disorders often confused with this malady, is readily understood by the statement that in frequency it ranks second only to poliomyelitis in the average clinic for crippled children in this country. Many children are added to the list each year, a few of whom can be helped considerably, while many others show involvement to such a degree that little can be accomplished with treatment, and little hope can be held out for their spontaneous improvement. The very nature of the condition is such that we will probably always be confronted with this problem; therefore it behooves us to understand the problem as clearly as possible in order that we may offer the maximum benefit to those patients with adequate prerequisites for treatment. The authors have seen at the Shriners' Hospital for Crippled Children in St. Louis 1720 consecutive cases of spastic paralysis and the other conditions which are frequently confused with it, and which must be considered in differential diagnosis. An attempt is here made to analyze these cases from the standpoint of classification, etiology, selection of cases suitable for surgery, and results from surgery.

GENERAL CLASSIFICATION

There has always been a great deal of confusion in attempting classification of the various lesions encountered in this group of cases. The problem can be clarified and the field adequately covered by grouping the cases under four major headings as seen in Table I.

Extrapyramidal Lesions

In this group of 224 cases, true congenital athetosis comprised 222 of the cases, and Wilson's disease (progressive hepatolenticular degeneration) the remaining two. True congenital athetosis is a motor disorder very frequently confused with, and erroneously classified as, spastic paralysis. Differentiation between these two is highly important, as they differ not only in the underlying pathological process, but also in their reaction to attempted therapy, both conservative and surgical. The condition was probably accurately described first by Hammond in 1869. This was later clarified by Davidian, and an accurate description of it can be clearly given by quoting from his article. "Athetosis is a motor disorder, characterized by a lesion, probably in the central ganglia or the fibres issu-

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 20, 1943.

TABLE I

Type of Involvement	No. of Cases
Extrapyramidal lesions	224
Impaired mentality	253
True cerebellar lesions	26
Pyramidal-tract lesions	1217
Total number of cases	1720

ing from them, that, directly or indirectly, irritate the nerves of the involved muscles, giving rise to adventitious movements, that are involuntary and incoordinate, tonic and deliberate, slow, irregular, and writhing provoked by a peripheral (sensory) or psychic stimulation, and highly aggravated on attempt at voluntary muscular action which becomes modified and distorted" with varying degrees of involvement, depending upon the severity of the affliction. Work in the neurosurgical field in more recent years shows that lesions in the premotor cortex may also account for a small percentage of these cases.

Wilson's disease, represented by the remaining two cases of the group, is a progressive bilateral degeneration of the lenticular nucleus with which there is always an associated hepatic cirrhosis. It is invariably fatal; shows a familial tendency; and is characterized by a tremor which changes later to severe tonic or clonic spasms involving all four extremities. Severe spasticity is present in every case, but no true muscle paralysis. The disease is progressive, resulting in total helplessness toward the end, with severe contractures. In spite of the associated hepatic cirrhosis, these patients usually present no definite signs or symptoms of liver disease during life. The nature of the disease is unknown, but there are

TABLE II

RESULTS FROM SURGERY IN EXTRAPYRAMIDAL LESIONS

Operative Procedure	Results		
	Good	Fair	Poor
Intrapelvic obturator neurectomy		2	
Biceps femoris transplant		1	2*
Popliteal neurectomy		1	
Heel-cord lengthening	1		
Triple arthrodesis		1	
Triple arthrodesis and heel-cord lengthening	1	2	
Triple arthrodesis, heel-cord lengthening, and popliteal neurectomy		2	
Transplant of peroneals to mid-tarsus (alone)		1	

* Recurvatum developed following operation.

some who feel that the disease is toxic; and that the toxin may be elaborated in the liver and have a specific action on the lenticular nucleus.

Surgical treatment in Wilson's disease is obviously contra-indicated, since the process is always fatal. The authors also feel that the entire group of pure extrapyramidal lesions should be considered unsatisfactory for surgery. In only ten of the 212 cases of congenital athetoses have orthopaedic procedures been employed. In general, surgical treatment is very disappointing. A suitable patient for surgical treatment must have an adequate sense of balance to allow walking without support, fixed deformity interfering with function, and a relatively mild degree of athetosis. The results of these fourteen operations are given in Table II.

These results were for the most part unsatisfactory, and the authors feel that in most instances the patients would have been as well off without the operations. The true congenital athetosis must of course not be confused with the primary lesions of the pyramidal tract associated with some athetosis, which will be discussed later.

First of all, the patient with true athetosis shows no constant fixed spasm with the pull invariably in the same direction, and, therefore, as a rule, fixed deformities do not develop. The spasms seen are fleeting in character, and even in the brief span of one examination, the involvement may shift from one muscle group to its opposing group with complete reversal of the position of the part.

Second, operations on the peripheral changes in the extremities do not alter the basic process, and the athetosis continues with recurrence of the original deformity or development of an exact opposite deformity in many instances.

Third, there is the difficulty encountered in postoperative care. In spite of the surgery, and plaster fixation, the athetosis continues unabated, and, in fact, is frequently increased in severity, with resultant pain, development of blisters, and often pressure sores. The plasters occasionally have to be removed. As stated previously, the authors feel surgery is seldom if ever indicated for this group of patients.

Impaired Mentality

In this group of 253 cases, 204 could be attributed to some developmental defect of the central nervous system (Table III). Of the remaining forty-nine, thirty-nine were secondary to an encephalitis, the child apparently having been normal prior to the illness. The other ten patients were true Mongolian idiots with slanting eyes, small head, short nose, thick protruding tongue, large abdomen, and thick short hands. Cases classified under the heading of impaired mentality showed no clinical evidence of motor defect, either pyramidal or extrapyramidal, and the mental deficiency was the most striking evidence of the involvement. Some cases were mild, with no involvement other than the lowered mentality, while others showed speech defects and an impaired sense of balance. It should be stressed at this point that the classification of these patients is based on

TABLE III

IMPAIRED MENTALITY (WITH NO MOTOR DEFECT)

Classification		No. of Cases
Simple mental deficiency		243
Maldevelopment of central nervous system	153	
Postencephalitis	39	
Microcephalus	36	
Hydrocephalus	15	
Mongolian idiocy		10
Total cases		253

the authors' own clinical examination and observations, and not on any recognized or scientific intelligence test. The importance of this group lies in the fact that they must be considered in differential diagnosis, and are often erroneously classified as "spastic". This error may be due to the fact that many of these patients are brought in with the primary complaint of inability to stand and walk.

These patients present no deformities, no surgery is indicated, and none has been attempted in the authors' cases. When these patients are seen in infancy, an accurate prognosis is impossible, and many of them have progressed far beyond the original estimate. In the more severe cases, however, institutional care is strongly advised.

True Cerebellar Lesions

The primary characteristic of the group of cerebellar lesions is their obvious ataxia. Friedreich's ataxia (seven cases), described first by Friedreich in 1863, is due to a progressive sclerosis or degeneration of the posterior and lateral columns of the cord. It is hereditary, characterized by a staggering gait, muscle weakness, absence of deep reflexes, later by ataxic movements in the hands, and ultimately by complete invalidism. Romberg and Babinski signs are usually present, and almost invariably there is an early bilateral equinus deformity of the foot.

Ten of these cases have been classified as cerebellar diplegia in which

TABLE IV

TRUE CEREBELLAR LESIONS

Classification	No. of Cases
Friedreich's ataxia	7
Cerebellar diplegia (no associated spasticity)	10
Unclassifiable cerebellar disorders	9
Total cases	26

there was no associated spasticity. In this condition, there is a diffuse symmetrical involvement, with muscle hypotonia and diminished or absent deep reflexes, and with ataxia and incoordination as the primary feature. It is probably due to a developmental defect or some degree of agenesis of the cerebellar hemispheres.[1]

The remaining nine cases are listed as unclassifiable, since they present pictures of cerebellar lesions not compatible with either of the first two groups. Most of these were thought to be due to cerebellar tumors and were referred to neurosurgeons; in some instances the tumors were found later at operation.

Orthopaedic surgical procedures are never indicated in these patients except perhaps rarely in the third group as a final reconstructive measure for correction of deformities persisting several years after the removal of the tumor. No orthopaedic measures have been attempted in the authors' cases.

Pyramidal-Tract Lesions

The true "spastics", or patients with lesions of the pyramidal tract, represent 1217 of the 1720 cases, or approximately 70 per cent. in this series. These cases are characterized by increased muscle tone, exaggerated deep reflexes, and almost invariably, by pathological toe signs, and ankle and patellar clonus. They are due to involvement of some portion of the pyramidal tracts, a definite lesion of the upper motor neuron, but it should be stressed that the involvement can be in any part of the paths of

TABLE V

Etiological Factors

Factors		No. of Cases
Obstetrics		774
Difficult delivery	362	
Forceps delivery	167	
Rapid delivery	3	
Caesarean section	9	
Prematurity,—1 and 2 months	118	
Asphyxia neonatorum	115	
Encephalitis		157
Transverse myelitis		27
Infection	5	
Trauma	22	
Cord tumor (low)		4
Tuberculosis of the spine		3
Spina bifida		12
Progressive degeneration from syphilis of the central nervous system		14
Intracranial neoplasm		10
Familial heredodegeneracy		1
Hereditary (family history of the disease)		17

the upper motor neurons, and is not necessarily limited to the cerebral hemispheres.

Many confusing and contradictory theories have been offered for the explanation of the etiology and pathogenesis of lesions of the pyramidal tract. No single theory can be accepted as an adequate explanation for all cases. Most cases can be classified correctly under one of three general headings:

1. Traumatic.
2. Developmental.
3. Infectious.

The traumatic factor (intracranial birth hemorrhage) has been supported by Little, and McNutt, and is commonly and perhaps erroneously accepted as the etiological factor most frequently encountered. This belief is not entirely substantiated by pathological findings, or by the clinical findings in any large series of cases. In this series, 362 patients (30 per cent.) had histories of abnormal and difficult deliveries, 167 of these having been delivered with the aid of forceps. There were three in which delivery was unusually rapid, each within a total time of two hours or less. In contrast to this, nine were delivered by Caesarean section, the mother not being permitted to go into labor. Little gave an excellent description of the true spastic child, and he felt that these cases were associated with either hemorrhage involving the central nervous system from injury at birth, or from changes in the central nervous system resulting from asphyxia neonatorum. Such asphyxia was present in 115 of the authors' cases, approximately 9 per cent. Schwartz and Fink, after many autopsies, found that intracerebral hemorrhages are frequent pathological findings in the newborn, and felt that these hemorrhages are due to the difference between intra-uterine pressure and the atmospheric pressure during the second stage of labor, rather than to actual trauma to the head during delivery.

The possibility of developmental defects being a factor is substantiated by the work of Freud, Collier, and Ironside. In the authors' cases, 118, approximately 10 per cent., were known to be premature by at least one or two months.

Neither of these theories can be definitely proved or universally applied. In general it seems to be accepted that paraplegic and quadriplegic cases are due to developmental defects of some form, since they show bilateral involvement, often symmetrical, with a high percentage showing other evidence of developmental disorders. In the hemiplegic and monoplegic cases on the other hand, it seems to be felt by most that some form of trauma with resultant hemorrhage can be considered as the etiological factor. Obviously there may be many exceptions in either case.

The third factor, infection, certainly accounts for a fair percentage of the true spastics. Strümpell has demonstrated pathologically postnatal diplegia and hemiplegia on the basis of polio-encephalitis. Virchow has

TABLE VI

Extremities Involved		No. of Cases
Hemiplegia		460
Quadriplegia (diplegia)		341
Paraplegia		304
Arm	0	
Leg	304	
Triplegia (hemiplegia and paraplegia)		73
Monoplegia		39
Arm	6	
Leg	33	
Total		1217

described intra-uterine and congenital encephalitis as etiological factors. In the authors' cases, 157 (13 per cent.) were known to be due to a definite postnatal encephalitis. These were patients who had developed sufficiently to be considered normal in every respect, prior to a distinct illness which was followed by symptoms and signs of spastic paralysis. Whether these are classified as due to encephalitis, encephalomyelitis, or polioencephalitis (if such exists) is only of academic interest and of no importance.

Lesions of the spinal cord can also account for spastic paralysis of the extremities,—usually a paraplegia involving the two lower extremities. Twenty-seven of these cases were thought to be secondary to a transverse myelitis, twenty-two of which were traumatic in origin and five infectious. Twelve cases, all spastic paraplegia, were thought to be due to a definite spina bifida defect of the lower-lumbar spine. These patients all had urinary and fecal incontinence, and showed no evidence of cerebral involvement. In four patients, the paraplegia, which was acquired later in life, resulted from tumors of the spinal cord involving the conus medullaris or cauda equina, and three were secondary to extradural abscesses associated with tuberculosis of the spine. The presence of cord tumors was proved at operation, and their removal resulted in marked improvement in three cases, but, in the fourth, a total flaccid paralysis involving both lower extremities was substituted. The three patients with extradural abscesses were completely relieved by laminectomy and removal of the tuberculous material.

It is interesting to speculate as to the exact mechanism by which spastic paralysis results when a lesion of the pyramidal tract is present. The commonly accepted theory is that the lesion completely interrupts the motor pathway and thus removes the higher inhibitory centers, leaving the lower reflex arcs intact and uncontrolled. It is possible that all the etiological factors listed could account for such an interruption. The fact that the spasticity sometimes disappears in patients with cord tumor or

TABLE VII

CONDITIONS ASSOCIATED WITH LESIONS OF THE PYRAMIDAL TRACT

Conditions		No. of Cases
Mental deficiency		446
Disturbance of speech		500
Impaired	325	
Complete absence	175	
Disturbance of balance		559
Impaired	354	
Complete absence	205	
Athetosis		286
Microcephalus		187
Hydrocephalus		32
Persistent epileptiform seizures (local or general)		124

tuberculosis of the spine after the neoplasm or abscess has been removed, however, causes one of us (H.R.M.) to feel that in some of these cases the spasticity may be due to simple irritation of the motor tracts with increased stimuli, rather than to an interruption of their pathways. Irritative lesions of the cerebral hemispheres from old hemorrhage, secondary scarring, and the inevitable scar contracture might conceivably produce irritative lesions of the motor cortex or connecting paths, resulting in a constant stream of impulses over the pyramidal tracts.

When classified from the standpoint of extremities involved, it is found that hemiplegia, quadriplegia, and paraplegia (lower extremities) constitute approximately 91 per cent. of all the pyramidal-tract lesions. Every possible combination of involvement has been encountered in this series except superior paraplegia involving only the upper extremities. For such involvement there must be two widely separated distinct lesions involving the arm area of each motor cortex or connecting tracts, leaving all the intervening motor mechanism uninvolved. While such involvement may be possible, it obviously is a rare picture and the authors have never seen one.

Monoplegia represents a relatively localized involvement of the motor cortex, or connections of the arm or leg area involved in the opposite cerebral hemisphere. Hemiplegia means involvement of the entire motor area in one hemisphere, affecting both the arm and leg areas. Triplegia constitutes involvement of the motor area of one entire hemisphere, with the lesion extending across the mid-line to include the leg area of the opposite side. Since the motor cortex in each cerebral lobe is inverted in relation to the level of the arm and leg, it is readily understood why a high percentage of paraplegia (lower extremity) is encountered. This means a mid-line lesion with extension laterally on each side to include the leg area of each cortex. This also explains why a similar involvement of the two arm areas alone, rarely, if ever, occurs. By quadriplegia, the authors

TABLE VIII

CONTRA-INDICATIONS FOR SURGICAL INTERVENTION IN LESIONS OF THE PYRAMIDAL TRACT

Reason	No. of Cases
1. Spasticity too mild	250
2. Associated severe athetosis	12
3. Associated, impaired, or absent sense of balance	140
4. Associated mental deficiency	34
5. Combination of all or of 2, 3, and 4	223
6. Miscellaneous causes	121
Total cases unsuitable for surgical treatment	780

mean an extensive widespread lesion including the entire motor cortex or connecting tracts of each side.

Only a small percentage of the lesions of the pyramidal tract show spasticity of the involved extremities without evidence of involvement of some other portion of the central nervous system. For lack of a better term these accompanying manifestations have been listed under the heading "associated conditions". The four most commonly encountered are impaired mentality, impaired speech, impaired sense of balance, and associated athetosis.

Some degree of mental deficiency was present in 446 (37 per cent.) of the 1217 pyramidal-tract lesions. The exact portions of the brain responsible for mentality are not definitely known, but these cases obviously represent a lesion in some portion of the brain other than the motor mechanism. Our lack of accurate knowledge in this regard is frequently covered up by merely stating they are due to involvement of the so-called "silent areas" of the brain.

Some speech disturbance was found in 500 cases, 41 per cent. of the total number. In 325 of these, there was simply an imperfect or impaired speech, with the patient retaining the ability to carry on a conversation, though frequently with considerable difficulty. In the remaining 175 patients, there was complete absence of intelligible speech, the child retaining the ability to make only a few weird, meaningless sounds. Two types of lesion can be responsible for this associated speech defect. An actual involvement of the motor areas supplying the muscles of speech may affect these muscles in the same manner that the extremity muscles are affected. It seems logical to assume that this type of lesion is probably responsible for most instances of imperfect and impaired speech. The second type of lesion is that in which the speech center itself is affected, and a developmental defect or even complete failure of development of this highly specialized center may be responsible for those cases in which speech is entirely absent.

Disturbance in the sense of balance was encountered in 559 cases (46

per cent.). This disturbance was responsible for an unsteady gait, often marked by frequent falls, in 354 instances. In the other 205 patients (17 per cent. of the total group), there was complete absence of the sense of balance, in which the patient never developed the ability to sit alone, stand alone, or walk without support. Such involvement may be the result of one of two lesions. First, there may be an associated subtentorial lesion resulting in interference with normal cerebellar function. Second, there may be a supratentorial lesion which involves not only the pyramidal tracts but also the cerebrocerebellar pathways, thus interfering with the normal function of the cerebellum in making possible coordinated movements, and the ability to maintain equilibrium in an upright position.

The presence of associated athetosis was demonstrated in 286 patients, or 23 per cent. of the entire group of true "spastics". In

FIG. 1-A

Fig. 1-A: Extreme adduction and internal-rotation deformity of both thighs.

Fig. 1-B: After correction by section of the adductors, anterior obturator neurectomy, and supracondylar derotational osteotomy, bilateral.

Fig. 1-C: Degree of active abduction possible after correction of the deformities.

FIG. 1-B

FIG. 1-C

these cases there is probably an involvement of the basal ganglia along with the pyramidal-tract lesion [2]. If the premotor cortex is responsible for athetoid movements at times, it is conceivable that, in some, this associated athetosis may be due to an extension of the same lesion forward to include the premotor as well as the motor area.

The remaining associated conditions as shown in Table VII are much less important and are self-explanatory.

TREATMENT

In comparison with many other conditions encountered in work with crippled children, the treatment of spastic paralysis is at times very disappointing. In selected cases, with adequate prerequisites, much can be accomplished by training and surgical correction of the deformities which so frequently result from the process. In general, treatment may be classified under two general headings, conservative and surgical.

Conservative treatment usually denotes training and physical therapy in an attempt to establish better muscle control and coordination, and thus bring about an improvement in function. Most of this work is carried out in schools for crippled children, while in many localities there are special institutions established for the care of these children over periods of years, in order to furnish them with adequate supervised training and physical therapy. That much can be accomplished in certain selected cases is not doubted, but it must be remembered at the same time that spontaneous improvement occurs in these patients, at least through their adolescent years, as a result of the normal development which takes place in the central nervous system. It is possible that much of the improvement which is credited to specialized training, may be due to nothing more than the normal developmental processes which continue with no treatment whatever. The authors feel that the ultimate and final picture in these cases in regard to mentality, speech, and the sense of balance, depends more upon the amount of development which takes place in the central nervous system than it does upon the amount or form of physical therapy which is used. This development of the central nervous system probably accounts for the improvement so frequently accredited to chiropractic, osteopathic, and other forms of non-surgical therapy.

This series of cases has not been analyzed from the standpoint of conservative treatment, though many have received excellent and prolonged physical therapy in the crippled children's school of the St. Louis public school system. Orthopaedic measures used in treatment have been primarily surgical, and the authors' further discussions on treatment will deal entirely with this phase of the subject.

Of the 1217 cases in this group, only 437 were considered suitable for surgery, while 64 per cent. of the pyramidal-tract lesions, and 74 per cent. of the 1720 cases of all types were considered unsatisfactory for an operative procedure. It may safely be said, then, that only about

26 per cent. of all patients seen are acceptable for attempted surgical correction of their deformities and spasticity. Table VIII shows the various reasons for rejection and the number thereof.

This table is self-explanatory and leads to a consideration of the requirements for acceptability for surgical correction of the deformities. These requirements are as follows:

1. Sense of balance adequate to walk without support.
2. Mild or no athetosis.
3. Mentality adequate to cooperate.
4. Preferably satisfactory speech.

The presence of little or no athetosis and the presence of a sense of balance adequate for weight-bearing and walking without support are absolute essentials before any such patient can be considered as a suitable

TABLE IX

SURGICAL TREATMENT AND RESULTS OF TRUE PYRAMIDAL-TRACT LESIONS AFFECTING THE UPPER EXTREMITY

Deformity	Operative Procedure	Results			
		Good	Fair	Poor	Unknown
Pronation of the forearm	Median nerve neurectomy		9	18	3
	Section of the pronator teres		2	3	
	Section of the pronator teres and median nerve neurectomy	1	1	4	1
	Pronator teres transplant	5	14	2	4
	Flexor carpi ulnaris transplanted to the extensor carpi radialis	1			
	Flexor carpi ulnaris transplanted to the extensor carpi radialis with section of the origin of the pronator teres	1	2		
	Reflection of the origin of the pronator teres			1	
	Osteotomy of the ulna		1	1	
	Osteotomy of the ulna and pronator transplant	1			
	Osteotomy of the radius and pronator transplant	1	1		1
Flexion of the wrist	Arthrodesis of the wrist *	4	20		
	Arthrodesis of the wrist and section of the pronator teres	1	1		
Miscellaneous	Arthrodesis of the thumb	1	6	2	
	Neurectomy of the nerve to short muscles of the thumb			1	
	Cervical sympathectomy			1	
Totals		16	57	33	9

* Secondary deformity resulted from epiphyseal injury at time of the operation in two cases.

candidate for reconstructive surgery. The presence of severe athetosis, as stated previously, complicates the postoperative care, and the results are not nearly so satisfying or so permanent.

In regard to the sense of balance, it is often argued that a patient cannot walk because of the deformities which are present. This the authors do not believe. They have seen many extreme and complicated deformities in this series of cases, but they have yet to see a patient whose deformities were severe enough to prevent walking if he possessed a satisfactory sense of balance. The degree of equilibrium present is an indication of the amount of development which has taken place in certain parts of the brain, and there is nothing which can be done to supply that function if it is absent. There are many instances in which this point of development may not be reached until the patient approaches puberty or even later. In this series, the ability to walk alone developed in twenty-one patients after they were six years of age, and fourteen of these learned to walk for the first time after their eighth year. Some patients have even been reported who first walked after reaching adult life, but these are extremely rare. Operative procedures for correction of deformities were carried out in thirty-four of the patients who were unable to walk; only six of them have ever developed to this extent, and in most of these six, the ability to walk did not come until some time later. The other twenty-eight patients never learned to walk in spite of the fact that the extremities were aligned satisfactorily for weight-bearing. Also in this regard, it should be stated that surgery should not be performed immediately after a patient has learned to walk. Instead, one should wait until the patient is steady on his feet and able to walk considerable distances without falling. If this is not done, the time spent in plaster may cause the patient to lose completely all ability to balance. The authors have seen such patients, who have been immobilized for several

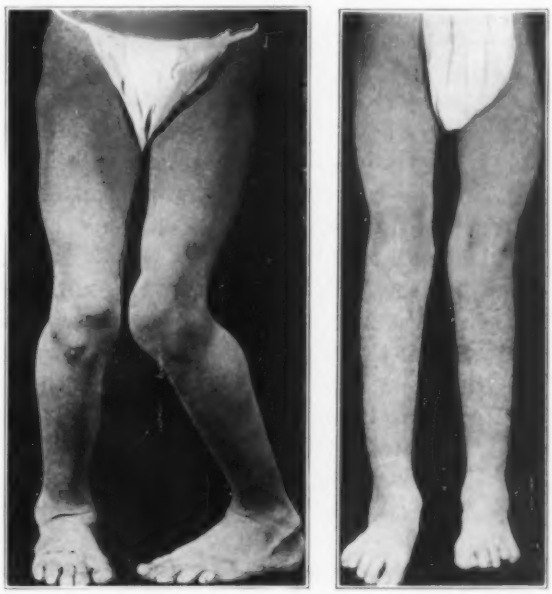

FIG. 2-A FIG. 2-B

Fig. 2-A: Internal rotation of the thighs and flexion deformity of the knees.

Fig. 2-B: After correction of the deformities by section of the gluteus medius and gluteus minimus, and transplant of the biceps and semitendinosus to the patella, bilateral.

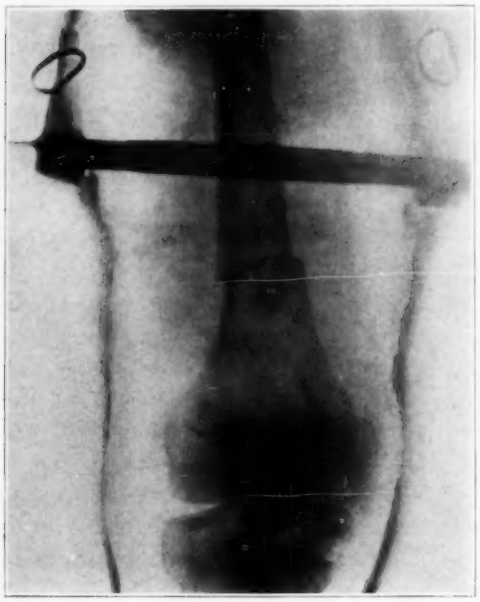

FIG. 3

Postoperative roentgenogram shows supracondylar-derotational osteotomy with wire fixation of the proximal fragment, for correction of internal-rotation deformity of the thigh.

weeks following surgery, lose all ability to walk, and require a year or more again to develop to the point they had reached prior to the operation.

The presence of satisfactory mentality and satisfactory speech is highly desirable, but is not such an absolute prerequisite for surgery as are the requirements already discussed. Some simple procedures may be performed in their absence for facilitating care and cleanliness of the patient, but the authors feel these factors should be present before any extensive reconstructive work is carried out. They are necessary for any patient if he is to take his place in society later, and if he is to become entirely or even partially independent and self-supporting. If there is obviously no hope of this, extensive reconstructive work is a waste of time and money.

In any isolated case of spastic paralysis, there may be an involvement of a single muscle group, leaving the rest of the extremity essentially free. In such instances, a single deformity is frequently encountered. In the great majority of cases, however, there is a diffuse involvement of an entire extremity, in which positions assumed and the deformities seen are always in the direction of the more powerful muscle groups. The direction of pull, therefore, is identical in every case of diffuse involvement, and the type of deformity which will be present can be predicted in advance. In the upper extremity, for instance, the shoulder is held relatively close to the body with limited abduction and in internal rotation. The elbow is flexed, the forearm is in pronation, and the wrist is flexed, with the fingers frequently in the same position. In the lower extremity, the hip is flexed, adducted, and internally rotated, the knee is flexed, and the foot is in equinus, sometimes with a varus or valgus shift in the lateral plane. The authors' surgical measures are directed toward correction of these deformities, altering the muscle pull by decreased power or transplantation in order to prevent a recurrence of the deformity, and in some instances altering it to prevent development of a fixed deformity. The actual surgical procedures used will be considered for each extremity, and for those deformities amenable to surgical correction.

TABLE X

SURGICAL TREATMENT AND RESULTS OF TRUE PYRAMIDAL-TRACT LESIONS AFFECTING THE LOWER EXTREMITY (HIP)

Deformity	Operative Procedure	Results			
		Good	Fair	Poor	Unknown
Adduction of thighs	Intrapelvic obturator neurectomy	34	23	21	4
	Section of adductors and anterior obturator neurectomy	97	16	3	4
	Section of adductors		4		
Internal rotation of thighs	Section of gluteus medius and gluteus minimus (Durham)	10	3	1	1
	Section of gluteus medius and gluteus minimus with section of iliotibial band	2			
	Neurectomy of nerve to tensor fasciae femoris		2	5	1
	Section of tensor fasciae femoris	3	3	4	2
	Supracondylar-derotational oesteotomy of femur	17	1		
Flexion of hips	Section of hip flexors	4	2		
	Transplant of origin of rectus femoris to femoral shaft			2	1
Totals		167	54	36	13

Upper Extremity

In general, surgical treatment of deformities of the upper extremity is quite unsatisfactory and the improvement which is obtained is frequently cosmetic rather than functional. The intricate detail of most of the functions in this extremity makes it almost impossible for any reconstructive work in a spastic child to fulfill the purpose for which it is intended. In this entire group of 1217 patients with lesions of the pyramidal tract, only 115 operations have been performed on the 437 suitable patients, and of these, only sixteen yielded a result which could be classified as good. By good is meant improved function and correction of the original deformity. The results of these operations are shown in Table IX.

The two deformities for which correction is attempted most frequently are pronation of the forearm and flexion of the wrist. For the first, the authors have used most frequently the pronator teres transplant in which the pull of this muscle is reversed, transforming it from a pronator into a supinator. Active function in the transplanted muscle is very rarely obtained, and the result is usually a partial correction of the deformity with no improvement in function. This type of result is listed as fair. Steindler has described transplantation dorsally of the flexor carpi ulnaris with insertion into the lower end of the radius, and

Green has described transplantation of the flexor carpi ulnaris into the extensor carpi radialis for use in improving supination. This latter method has been used in four of these cases, in three of them being combined with section of the pronator teres for correction of the original deformity. This operation has also been done in a few other patients who have been followed for an insufficient length of time to be included in this report, and it is the authors' impression in this limited experience that the results from it are only fair. No procedure can be considered entirely satisfactory, and the result obtained is usually partial correction of the deformity without much improvement in function.

Flexion deformity of the wrist is best treated by arthrodesis of the carpal bones to the lower end of the radius. This has been used in twenty-four cases, and in four instances there was complete correction of the deformity with definite improved function in the hand and fingers. These have been classed as good. In the other twenty, correction of the deformity was obtained, but there was no change in the function of the hand or fingers. These have been classed as fair since the improvement obtained was purely cosmetic.

Lower Extremity

Surgical correction of deformities in the lower extremity is far more

TABLE XI

SURGICAL TREATMENT AND RESULTS OF TRUE PYRAMIDAL-TRACT LESIONS AFFECTING THE LOWER EXTREMITY (KNEE)

Deformity	Operative Procedure	Results			
		Good	Fair	Poor	Unknown
Flexion of the knee	Biceps transplant alone *†	46	8	3	6
	Biceps and semitendinosus transplant	9	1		
	Advancement of tibial tubercle (Chandler)	5			
	Advancement of tibial tubercle and inner hamstrings section *	2			
	Biceps transplant and section of inner hamstrings	5	2		
	Section of inner hamstrings and iliotibial band (biceps left for subsequent transplant)	9	16	15	4
	Hamstring neurectomy	6	19	15	2
	Transplant or origin of hamstrings	1	1		
	Lengthening of hamstrings			1	
Totals		83	47	34	12

* Secondary recurvatum deformities developed after biceps transplant alone in eleven cases and after advancement of the tibial tubercle and inner hamstrings section in two.

† Secondary lateral subluxation of the patella developed after biceps transplant alone in one case.

satisfactory than in the upper, due partially at least to the fact that function in the lower extremities is not nearly so detailed and exacting. In this series of 1217 lesions of the pyramidal tract, 1063 operations have been performed on the lower extremities with 677 good results. Individual tables showing results after attempted correction of deformities at the hip, the knee, and the foot are given, with the procedures used and the results obtained in each (Tables X, XI, XII).

For the adduction deformity of the thigh and correction of the "scissors gait" two procedures are in common use,—namely, intrapelvic obturator neurectomy [16], and section of adductors with anterior obturator neurectomy [19]. The latter gives a higher percentage of satisfactory results, since it not only provides interruption of this portion of the nerve pathway, but also permits section of the contracted adductor longus and gracilis. When the neurectomy is done intrapelvically, the actual fixed contracture of these muscles often interferes with correction of the deformity, even though the power of the adductor pull is diminished.

FIG. 4-A

FIG. 4-B

Fig. 4-A: Flexion deformity of the knees.

Fig. 4-B: After correction of the deformity by transplantation of tibial tubercle to a lower level on the shaft of the tibia (Chandler), bilateral.

For internal rotation of the thighs, there is a choice of two satisfactory procedures, each of which has its indications. These are section of the gluteus medius and gluteus minimus, as described by Durham, and supracondylar derotational osteotomy. In some cases, a moderate position of internal rotation is assumed when walking, from the spasm which occurs in the gluteus medius and gluteus minimus on active innervation. These are not fixed deformities, and adequate section of the two muscles near their points of insertion, which in reality is comparable to a lengthening of the muscles, affords satisfactory correction. Good results have been obtained in ten of the fifteen cases of this type in which this procedure has been used. These results are better than those which were obtained by section of the tensor fasciae femoris alone, although in some of the Durham operations the iliotibial band has also been divided.

There are cases, however, in which the internal rotation of the thigh is a constant fixed deformity, not merely one which becomes apparent on active innervation. The rotation in these patients cannot be entirely corrected passively. This is felt to be due to actual organic contracture in the gluteus medius and gluteus minimus, in the tensor fasciae femoris, which is the third powerful internal rotator of the thigh, and also in all of the soft-tissue structures about the hip joint. In some instances of long standing, there may even be some change in the contour of the femoral head and acetabulum. In this type of deformity, section of the gluteus medius and gluteus minimus does not afford correction of the deformity, as the fixed secondary change in the other structures prevents any active or passive external rotation of the hip. In such cases the hip is left in internal rotation, in fact is internally rotated as far as possible, and a supracondylar-derotational osteotomy is used, the distal fragment being externally rotated until the knee and the foot are properly realigned with the anterior superior spine. The proximal fragment is fixed in the maximum amount of internal rotation by means of a transfixing wire just above the site of osteotomy. Satisfactory results are almost invariably obtained with this procedure, since the hip is fixed in internal rotation and cannot possibly internally rotate further, and there is therefore no recurrence of the deformity. In eighteen cases in which this procedure has been used, good results with complete correction of the deformity have been obtained in seventeen instances. It is not used in the milder cases simply because it is a more difficult operative procedure and the period of postoperative fixation is longer.

FIG. 5-A

FIG. 5-B

Fixed equinus deformity corrected by heel-cord lengthening and popliteal neurectomy.

Flexion deformity of the hip occurs quite frequently, but is very seldom present to such a degree that it interferes with adequate function. When correction is justified, simple subcutaneous tenotomy of the structures attached to the anterior superior spine and to the aponeurosis extending laterally and posteriorly from this point affords very satisfactory relief. In very severe cases, the more

extensive fasciotomy as described by Soutter may be used, but its indications are certainly rare.

For correction of flexion deformity of the knee, many different procedures have been used as shown in Table XI. Their present knowledge of the results obtained leads the authors to choose between two procedures, namely, advancement of the tibial tubercle as described by Chandler, or hamstring transplantation. Results obtained by other means have yielded an unsatisfactory number of good results. An attempt is made to choose the cases suitable for each procedure according to the degree of involvement which they show.

If the deformity can be almost completely corrected passively, and is assumed only on active innervation under weight-bearing, advancement of the tibial tubercle is used. The use of this operation in children is contra-indicated according to Chandler because of the danger of injury to the epiphyseal line. The authors have used it several times for transplantation of the tibial tubercle in this condition and also in correction of subluxation of the patella, and have yet to see a deformity resulting from injury to the growth structure. No large block of bone is removed, but instead the patellar tendon is detached by driving an osteotome along its posterior margin, parallel to the long axis of the tibia and shaving off only a small superficial portion of the bone. Two instances of genu recurvatum have been encountered following advancement of the tubercle and section of the inner hamstrings, but these resulted from marked muscle imbalance and not from injury to the epiphyseal line. This operation has been done in more cases than are listed in Table XI, but they have been followed an insufficient length of time to classify their end results.

If the flexion deformity of the knee is fixed and must be corrected by a series of wedging plasters prior

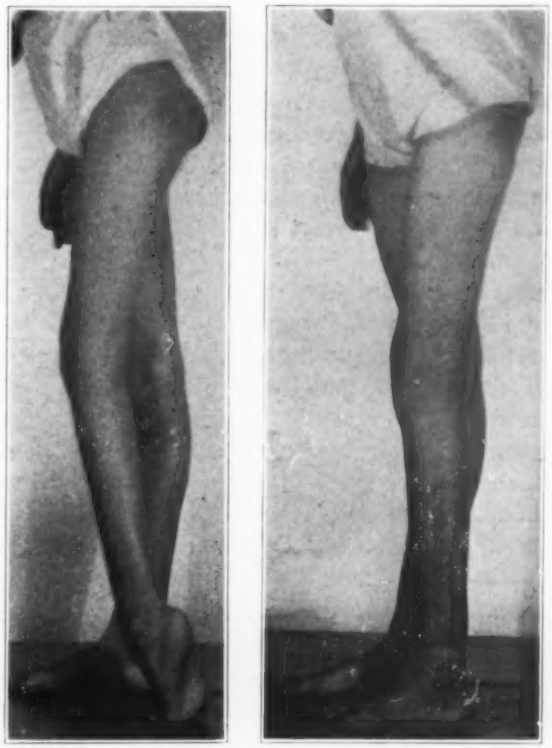

FIG. 6-A FIG. 6-B

Fixed equinus deformity corrected by heel-cord lengthening and triple arthrodesis.

TABLE XII

SURGICAL TREATMENT AND RESULTS IN TRUE PYRAMIDAL-TRACT LESIONS AFFECTING THE LOWER EXTREMITY (FOOT)

Deformity	Operative Procedure	Results			
		Good	Fair	Poor	Unknown
Equinus of foot	Popliteal neurectomy	77	35	51	11
	Heel-cord lengthening *	70	15	12	9
	Wedging plasters	2			
	Heel-cord lengthening and popliteal neurectomy †	113	9	6	10
	Heel-cord lengthening and foot stabilization	46	4		5
	Heel-cord lengthening, popliteal neurectomy, and foot stabilization	31	1		1
Other foot deformities	Stabilization of foot	39	4	2	1
	Stabilization of foot followed by tendon transplants	30	2		1
Totals		408	70	71	38

* Secondary calcaneus deformity resulted in one case.
† Secondary calcaneus deformity resulted in three cases.

to operation, a hamstring transplantation is performed on the theory that simple advancement of the tibial tubercle would be insufficient to prevent a recurrence of the deformity. Transplantation of the biceps femoris alone to the patella has been used in the largest number of cases in this series, and has yielded satisfactory results (68 per cent. good of the known results). In this series, as shown in Table XI, eleven instances of genu recurvatum have been encountered, but most of these were in cases in which an earlier attempt at correction had been made by complete section of the two inner hamstrings, the biceps having been left for subsequent transplantation if the deformity recurred. When the biceps transplant alone is used, lateral subluxation of the patella will occasionally occur from the strong, imbalanced, lateral pull, though this is infrequent in spastic paralysis. In more recent years, the authors have used with satisfactory results transplantation of both the biceps femoris and semitendinosus to the patella, in order to give a balanced pull on the patella. Here again, the procedure has been used in more cases than are listed, but these additional cases are too recent for final classification.

Operative procedures for correction of deformities about the feet represent about 55 per cent. of all the operations performed in this group of cases, which is an indication as to the frequency of foot deformities in this disease. Fortunately it offers the highest percentage of satisfactory results. The simple equinus deformity is the one most frequently encountered. If this is only a mild deformity resulting from the spasm which appears on active innervation and in which there is no organic

TABLE XIII

MISCELLANEOUS OPERATIVE PROCEDURES USED IN TREATMENT OF TRUE PYRAMIDAL-TRACT LESIONS OF THE LOWER EXTREMITY

Operative Procedure	Results			
	Good	Fair	Poor	Unknown
Section of the peroneal tendons for valgus-foot		1		
Crushing the nerve supply to the peroneals for valgus-foot			1	
Section of the plantar fascia for cavus-foot	2	2	1	
Jones' suspension	7	2		
Hibbs' suspension	1			
Section of the posterior tibial tendon for varus-foot		2	1	1
Section of toe flexors	1			
Tibial turn after supracondylar-derotational osteotomy	7			
Osteotomy of the tibia and fibula	1			

contracture of the heel cord, popliteal neurectomy (excision of the nerve supply to the two heads of the gastrocnemius) alone is used. Such a deformity is frequently encountered in very young children and this simple procedure usually permits them to approximate the heel to the floor with each step. In many instances the soleus will become hypertrophic in subsequent years to equal the original power of the entire calf group, with a recurrence of the deformity. Such recurrences have been seen in fifty-one of 174 cases; permanent satisfactory correction was obtained in seventy-seven cases, or 44 per cent. When the deformity has recurred, it has been later recorrected by heel-cord lengthening.

When structural shortening of the heel cord can be demonstrated in the beginning, lengthening of this shortened structure is obviously necessary in order to correct the deformity. Subcutaneous tenotomy of the heel cord should never be used in spastic paralysis, as spasm of the calf group will result in wide separation of the fragments, complete non-union of the tendon, and a marked secondary calcaneus deformity. Though the authors have never used the procedure, six such deformities have been seen in cases treated elsewhere. Heel-cord lengthening has been used in 106 cases with good results obtained in seventy, or 66 per cent. In this regard, there is always the question of combining heel-cord lengthening with popliteal neurectomy as the initial procedure. The authors, in fact, prefer the latter, but one must be careful not to lengthen the heel cord too far, as three calcaneus deformities have developed in the 138 cases in which it has been used. The heel cord is lengthened only sufficiently to permit dorsiflexion of the foot to a right angle. With the combined procedures, good results have been obtained in 82 per cent. of the cases, with only 4 per cent. recurrent deformities as compared with 66 per cent. good results, and 11 per cent. recurrences from heel-cord lengthening alone.

When this deformity recurs after both heel-cord lengthening and popliteal neurectomy have been done, when the fixed equinus has been

present long enough for development of a true bone deformity of the foot, or when there is an associated varus or valgus element in addition to the equinus, stabilization of the foot must be done for a satisfactory result. In this series, it has been performed alone in forty-six cases, in conjunction with heel-cord lengthening in fifty-five cases, with both heel-cord lengthening and popliteal neurectomy in thirty-three cases, and in conjunction with tendon transplantations about the foot in thirty-three cases, or a total of 167 cases. Of all the cases in which foot stabilization has been used, 87 per cent. have yielded good results, with permanent satisfactory correction of the deformity. It must therefore be classed as the most satisfactory single operative procedure we have in the treatment of spastic paralysis, being combined of course with heel-cord lengthening when necessary, and occasionally with tendon transplants. The only tendon transplantations which have been used, except in isolated cases, have been shifting the anterior tibial to the mid-tarsus to prevent a recurrent varus deformity or shifting the extensor hallucis longus to the first metatarsal to control a cock-up of the great toe.

The results of operative procedures for thirty miscellaneous deformities of the lower extremity are given in Table XIII.

SUMMARY

A series of 1720 consecutive cases of spastic paralysis and allied disorders are herein analyzed from the standpoint of classification, characteristics of each class, and etiology. The 1217 cases of lesions of the pyramidal tract are discussed in detail from the standpoint of the extremities involved, associated conditions, requirements or prerequisites for surgical correction of the deformities, and reasons for non-intervention in those cases rejected for surgery. The various deformities encountered in both upper and lower extremities are then discussed with the various operations which have been used, together with the results obtained. An attempt is made to establish some rationale for the selection of the most desirable operation in each type of deformity.

The total number of operations on the upper extremities was 115 with only sixteen good results. Surgical treatment on the whole is unsatisfactory, with improvement primarily cosmetic, not functional. Attempts at correction of deformities in the upper extremity are justified for:

1. Pronation of the forearm,
2. Flexion of the wrist.

The total number of operations on the lower extremities was 1063 with 677 good results. Surgical treatment on the whole is satisfactory, and should be attempted for:

1. Adduction of the thighs,
2. Internal rotation of the thighs,
3. Flexion deformity of the knees,
4. Spasm or contracture of the heel cord,
5. Other fixed foot deformities.

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A STUDY OF SUBTROCHANTERIC OSTEOTOMY *

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Subtrochanteric osteotomy was first described more than a century ago. Barton, in 1827, wrote about the case of a sailor who had sustained a hip injury while aboard ship. The injury resulted in a flexion-adduction deformity. The diagram, accompanying the report of this case bears a striking resemblance to diagrams appearing in modern orthopaedic textbooks [5,9]. The surgeons of the time had a fairly clear conception of the deformity, yet disappointment awaited them, when they discovered that a transverse subtrochanteric osteotomy would not produce an artificial joint.

While subtrochanteric osteotomy is one of the most common orthopaedic procedures used in surgery about the hip joint, there has not been a corresponding volume of literature published on the subject.

One hundred consecutive cases of subtrochanteric osteotomy, performed at the New York Orthopaedic Dispensary and Hospital during the years 1930 to 1939, inclusive, were reviewed for the purpose of making an analysis of the work done, and, if indicated, of discovering measures for improving the end results. All cases in this study had been followed for at least two years.

The operation was performed on fifty-nine patients with fused hips and on forty-one patients with mobile hips.

The youngest patient operated upon was two years old, and the oldest, thirty-two years. Tables I and II indicate the various diagnoses in the cases studied. The types of deformities present in the fused-hip cases, and the nature of limited motion in the mobile hips is recorded in Tables III and IV. The deformities present, in addition to those at the hip, are noted in Tables V and VI.

In the patients with a fused hip, the leg was shorter in nineteen cases and longer in fifteen cases, following operation. There were twenty-five cases showing no change in leg length. In the mobile-hip series, the leg was shorter in fifteen cases, longer in eight cases, and had no change in twelve cases; six were not recorded.

In general, in the cases in which the principal deformity was that of adduction, a change to a position of abduction resulted in a shortening of the leg. This change in position also produced functional lengthening by tilting the pelvis. In cases in which the principal deformity was abduction, a change to less abduction or neutral position resulted in an increase in leg length. In the large number of cases (twenty-five) where no

* Presented at a meeting of the Boston Orthopaedic Club, Boston, Massachusetts, November 16, 1942.

TABLE 1

DIAGNOSES IN CASES OF FUSED HIPS

Diagnosis	No. of Cases
Tuberculosis of the hip	39
Suppurative arthritis	14
Luetic arthritis of the hip	2
Old coxa plana (hip had been previously fused)	1
Myositis ossificans (hip had been fused following radium burn)	1
Congenital dislocation (hip had been fused)	1
Ankylosis of the hip following extensive burn	1
Total	59

TABLE II

DIAGNOSES IN CASES OF MOBILE HIPS

Diagnosis	No. of Cases
Congenital coxa vara	19
Slipped upper femoral epiphysis	8
Suppurative arthritis of the hip	4
Congenital dislocation of the hip	2
Chondrodystrophy	2
Fracture of the neck of the femur	5
Congenital shortening	1
Total	41

change in length was recorded, the deformity was that of flexion adduction, with the amount of flexion greater than that of adduction. The high curved osteotomy in itself did not alter the leg length.

A high curved osteotomy, following the principles employed by Brackett, Gant, and Cotton, was performed in fifty-three of the cases of fused hips. The osteotomy was completed with a long lip on the medial, lateral, or anterior aspect of the femur, depending upon the deformity which required correction. One oblique osteotomy, one cuneiform osteotomy, and four high, transverse osteotomies were also done in this series. In the mobile hips, a high curved osteotomy was done in thirty-two cases, a transverse osteotomy in three cases, and a cuneiform osteotomy in six cases. Adductor tenotomy was done when indicated. It was not necessary to use internal fixation when the high curved osteotomy was done in the fused hips. In the mobile hips, the fragments were wired, or secured with suture material, or a nail was placed in the greater trochanter to control the proximal fragment, depending upon the operator's estimate of the situation. Inability to control the proximal fragment in the mobile hips was a common experience.

TABLE III

TYPES OF DEFORMITY IN FUSED HIPS

Deformity	No. of Cases
Flexion-adduction	9
Flexion-adduction with external rotation	6
Flexion-adduction with internal rotation	16
Flexion-abduction	6
Flexion-abduction with external rotation	20
Flexion-abduction with internal rotation	0
Flexion with external rotation	1
Flexion with internal rotation	1
Total	59

TABLE IV

TYPES OF DEFORMITY IN MOBILE HIPS

Deformity	No. of Cases
Limited abduction	12
Limited abduction and internal rotation	12
Limited abduction and external rotation	2
Limited abduction, internal and external rotation	4
Limited abduction and flexion	1
Limited flexion and internal rotation	1
Limited flexion, abduction, and internal rotation	5
All motions limited	2
Abduction deformity	1
Flexion deformity with no abduction	1
Total	41

In the majority of all cases, the operator sought to place the extremity in approximately 20 degrees of flexion, 15 degrees of abduction, and in neutral rotary position. In mobile hips, it was frequently necessary to place the hip in greater flexion in order to approximate the fragments. The position of the hip was determined by the operator's estimate without the use of a goniometer or like instrument.

In six of the 100 patients, single spicas were used, and four of the six patients thus immobilized required reoperation because of loss of position.

Eleven cases required wedging of the plaster to correct position. The spica was changed in ten cases, and, in seventy-nine cases, the original cast was removed, usually at ten weeks, and after clinical examination and check-up roentgenograms had indicated that the progress was satisfactory. Approximately 50 per cent. of the patients in the fused-hip series had an increase in the amount of flexion deformity, when the plaster was removed, as compared with that position recorded just prior to the operation. In

TABLE V

DEFORMITIES ASSOCIATED WITH FUSED HIPS

Deformity	No. of Cases
Genu valgum	17
External tibial torsion	4
Increased lumbar lordosis	3
Flexion deformity of the knee	2
Compensatory lumbar scoliosis	3
Relaxed unstable knee	3
Recurvatum of the knee	4
Total deformities associated with fused hips	36
No other deformities	23
Total	59

TABLE VI

DEFORMITIES ASSOCIATED WITH MOBILE HIPS

Deformity	No. of Cases
Genu valgum	4
Increased lumbar lordosis	1
External tibial torsion	1
Recurvatum of the knee	2
Genu varum	2
Flexion deformity of the knee	2
Flat-foot	5
Total deformities associated with mobile hips	17
No other deformities	24
Total	41

the mobile-hip series, the data of recorded position before operation, at operation, and after removal of plaster was not sufficiently consistent and accurate to give details. In no case, however, was the flexion less after operation.

In general, the valgus position of the fragments in cases of coxa vara was maintained, and full extension subsequently was obtained in those cases in which it was necessary to place the hip in considerable flexion in order to approximate the fragments.

The usual time before weight-bearing was twelve weeks following operation.

While there was a suggestion of a tendency for flexion to increase during the first year after operation, there was no appreciable change in position at one year or at the "last-known position" when compared with

the position recorded at the time the plaster was removed. Any estimates of angles of less than 10 degrees were not considered, as the examinations were made by several men and clinical estimates are liable to a reasonable degree of error. Where comparative measurements were made with goniometer, the data was considered more reliable.

In the series of 100 patients, eight required reoperation because of poor position. Operation was recommended in three other cases making a total of eleven cases which were not satisfactory. The remaining eighty-nine cases were considered to have satisfactory end results. Each of the eight patients who had a second operation had a satisfactory position following the second operation. The average length of time required to obtain sufficient union to allow weight-bearing was ten weeks.

COMMENT

Subtrochanteric osteotomy is a useful procedure in correcting the deformities resulting from a large variety of pathological conditions about the hip joint.

The types of deformity encountered in the cases studied were variable, as indicated in Tables III and IV. The number of cases of abduction deformity was greater than might be expected. This may be explained by the fact that many of the patients with fused hips had had a previous hip fusion for tuberculosis, and the extremity had been placed in abduction and flexion at the time of operation, and had fused solidly in that position, with the amount of flexion, and occasionally abduction, later increasing in amount.

While this change in position was taking place, the extremity frequently assumed a position of external rotation. The resulting deformity required a subtrochanteric osteotomy to correct the position. If a tuberculous hip is allowed to fuse spontaneously, it is expected that the resulting deformity will be that of flexion-adduction, due to the superior power of the flexion and adduction muscles as compared with their antagonists.

In the patients with fused hips, the nearest distal joint, the knee, frequently showed relaxation of the ligaments as evidenced by increased anteroposterior and lateral motion. This did not occur in the mobile-hip series. A comparison of leg lengths before and after operation showed increased length, decreased length, or no change, depending upon the deformity present before the operation. The high curved osteotomy alone does not alter the leg length. Cuneiform osteotomy shortens the leg.

Skeletons were measured with the hip in neutral, and in various degrees of abduction and adduction, to determine normal changes in length as measured from the anterior superior spine to the medial malleolus.

As is well known, any increase in abduction from a neutral position will give a shorter measurement. A longer length is obtained as the leg is adducted, until a point is reached where the line passes through the center of the head of the femur. Further adduction beyond this point again results in a shorter measurement. (See Figure 1.)

The findings differed to some extent on the cadavera and on the clinic

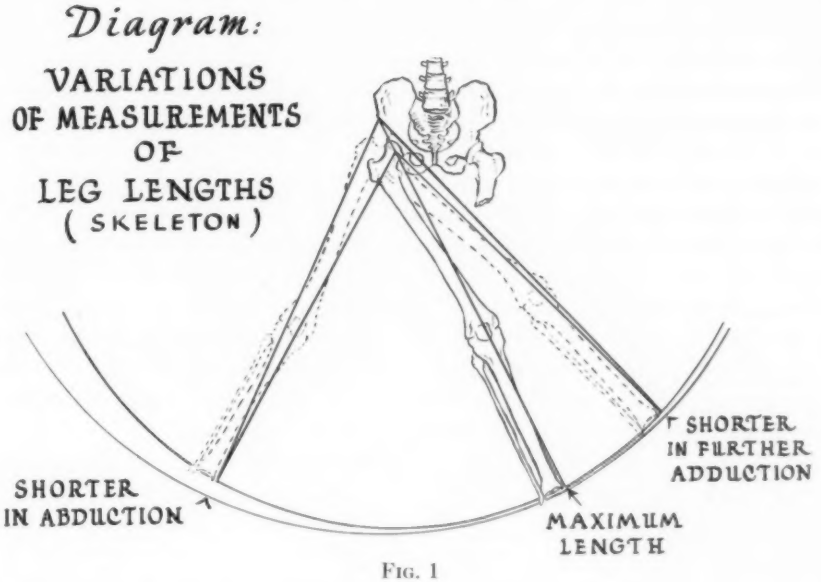

FIG. 1

patients. Abduction from neutral resulted in a shorter measurement. However, the initial lengthening in adduction was not obtained because it was necessary to flex the hip in order to clear the opposite leg, and the shortening was greater when adduction was increased beyond a point where the line passed through the center of the head, when compared with the same degree of adduction on the skeleton.

In fused hips, a high curved osteotomy is desirable because flexion, adduction, abduction, and rotation can be corrected by this type of osteotomy without shortening the leg, and in addition, the position of the fragments can be controlled.

In the mobile hips, greater difficulty is encountered in controlling the fragments and obtaining the desired position. Superiority in muscle power tends to flex the proximal fragment and adduct the distal fragment. In some cases of mobile hips, it is desirable to calculate the required amount of abduction needed, by determining the amount of mobility present at the hip, and estimating the degree of abduction necessary to restore the head to proper relationship with the acetabulum. The abduction osteotometer described by Milch may prove to be of assistance in facilitating the calculations. Considering the difficulty encountered in maintaining the position of the fragments at the site of the osteotomy, the procedure of doing an arthrodesing operation and osteotomy at one operation, as recommended by Briggs, must be considered an ambitious undertaking. The block osteotomy described by Ryerson is a desirable operation in a limited field where curvature of the femur is present. The principle of angulating the proximal fragment medially against the pelvis with the distal fragment parallel to the opposite femur, as suggested by Schanz, is recommended when indications are present.

Adductor tenotomy was done when indicated. While it was not found necessary in this series to do an open hip-flexion release of contracted soft-tissue structures as described by Soutter, and Campbell [4], such procedure is recommended when indicated.

The position of 20 degrees of flexion, 15 degrees of abduction, and neutral rotation which was sought in many of these cases, is not considered the most desirable one. A careful observation of the gaits of thirty-five patients revealed that those patients whose hips were placed in 25 degrees of flexion, neutral lateral, and neutral rotary position, had the most desirable gaits. Indeed, in most cases it was hard to detect a limp in the gait of those patients whose hips had been fused in the position mentioned. These patients walked with the least limp and there was no complaint in sitting, standing, or walking. The patients had long since forgotten that they had anything wrong with their hips.

In those cases in which the leg was placed in 15 to 20 degrees or more of abduction, the patients walked by throwing the leg laterally in a semicircle, a swinging motion to clear the toes from the floor. This movement was more pronounced when there was less than an inch of shortening. In placing the extremity in neutral lateral position, consideration must be given to the amount of shortening and the flexibility of the lumbar spine. If the shortening is greater than one and one-half inches, 5 to 10 degrees of abduction will result in a better gait, but this angle should not be exceeded.

Care must also be taken not to place the legs with knock-knee in too much abduction. The operators made no mention in their notes that the opposite hip had been flexed, flattening the lumbar spine, and the amount of flexion then estimated. No instruments for measuring position were used at the time of operation.

It is recognized that it is difficult to immobilize the pelvis. A carefully applied, snugly fitting, double spica, extending well above the nipples, is necessary. Fifty per cent. of the patients with fused hips showed an increase in flexion deformity when the plaster was removed. While it is probably true that a comparison of position on the operating table with the position out of plaster is subject to some variation, the high percentage of cases showing increased flexion when out of plaster is significant. The loss of position occurred while closing the operative wound, during the application of plaster, or during the weeks the pelvis and extremities were presumably immobilized in plaster, and, in this series, was not caused by change in position at the hip joint, due to an unhealed bone lesion or formation of scar tissue as suggested by Downing.

In one case in the series, a pseudarthrosis developed at the osteotomy site. This cast had been previously wedged. With the above exception, union took place readily in the other ninety-nine cases. The average time required was ten weeks.

A record of the activities of the patients was made. The data was revealing. Many patients with fused hips, who had had a subtrochanteric osteotomy, went about their routine work and gave no thought to

their hips, excepting when requested to report for follow-up study. Their occupations were varied. In the younger group, the majority of the patients participated in one or more of the following forms of recreation: hiking, swimming, tennis, handball, dancing, and baseball. In addition to the above list, two patients in the fused-hip group, participated in high-school football in competition with other teams, and two patients in the mobile-hip group, were members of their high-school track teams. One boy ran in the 220-yard dash, and the second was a member of the cross-country team.

SUMMARY

From an analysis of 100 consecutive cases of subtrochanteric osteotomy the following recommendations are made:

1. The ideal position in cases of fused hips is that of 25 degrees of flexion, neutral lateral position, and neutral rotation. Patients whose hips are fused in the above position have the best gaits, and do not complain while sitting, standing, or walking. In those cases where the shortening is more than one and one-half inches, 5 to 10 degrees of abduction is recommended.

2. A high curved subtrochanteric osteotomy is recommended to correct deformities at the hip joint when operation on bone is indicated. Abduction, adduction, flexion, and rotation can be readily corrected without sacrificing leg length.

3. The position desired to produce a successful result can be obtained by attention to detail. When the osteotomy has been performed, the opposite hip should be flexed, flattening the lumbar spine. The extremity should be held in the desired position, with the aid of assistants if necessary, until the fragments are immobilized in plaster. The operator should use a goniometer, if he is not satisfied with his clinical estimate of position.

4. The difficulty of immobilizing the pelvis is recognized. A snugly fitting double plaster-of-Paris spica, extending well above the nipples, is necessary. The opposite hip should be in abduction.

5. When a subtrochanteric osteotomy is done in the presence of a mobile hip, the use of the Roger Anderson pin apparatus or skeletal traction may be of assistance to the operator in controlling the fragments. The Roger Anderson apparatus should not be used unless the operator is trained in the technique, and is aware of the attendant dangers.

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TREATMENT AND RESULTS IN LOCALIZED OSTEITIS FIBROSA CYSTICA (THE SOLITARY BONE CYST)

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The term osteitis fibrosa, of either solid or cystic form, cannot be linked accurately with any single bone lesion. The process is essentially a reparative one, in which a local area of bone destruction becomes walled off by a zone of fibrosing osteitis. It is seen in inflammatory, neoplastic, and metabolic diseases, and also as a response to mechanical injury of bone. There are, however, three types of fibrocystic disease of bone that form distinct clinical entities.

The generalized form of osteitis fibrosa cystica was described by von Recklinghausen in 1891, and the disease bears his name. Mandl showed its association with an adenoma of the parathyroid gland in 1926. Compere has made an exhaustive study of the blood chemistry; he has shown that the changes which are so characteristic in the generalized form are not found in the regional and localized varieties.

In regional fibrocystic disease, the whole skeleton is not involved, but the process does extend beyond a single local area. Freund and Meffert have described a monostatic form in which there was general involvement of a single bone, a unilateral type in which several bones on one side only of the body were affected, and a monomelic variety in which the disease was limited to one extremity with lesions in two or more bones. The process is believed to be due to a congenital defect in bone development.

Localized osteitis fibrosa cystica, or the solitary bone cyst, is a benign lesion, usually manifesting itself before the age of fifteen years. It begins on the metaphyseal side of the epiphyseal line, and is most commonly seen at the upper end of the humerus, femur, or tibia. As the bone lengthens, the cyst moves down its shaft and may be at some distance from the epiphyseal line when first discovered.

Pathological fracture is very common, and is the usual reason for seeking medical attention. Other patients may complain of aching pain, or a painful limp may develop. Again there may be no symptoms, and the cyst is an incidental finding in roentgenograms taken for other reasons.

On roentgenographic examination, the cyst is found to be expansile in type, and limited by cortical bone. The ensheathing layer of fibrosing osteitis is more or less definite, and it may be very indistinct toward the medullary cavity. Trabeculae often cross the cyst.

When opened, the cyst is usually filled with a thin, greenish-brown fluid, and is lined with a layer of connective tissue, stained by the fluid. Rarely it may be filled with fibrous tissue, or there may be no lining

TABLE I

CASES OF FRACTURE THROUGH THE CYST TREATED BY IMMOBILIZATION

Name	Sex	Age (*Years*)	Site	Symptoms	Treament	Result
P. B.	M	13	Femur, upper end.	Fracture.	Traction followed by hip spica.	*7 months later.* No complaints, full function, no shortening, three-quarters of an inch of atrophy of thigh. Roentgenogram shows cyst almost obliterated and the bone strong.
D. C.	F	7	Femur, upper end.	Fracture.	Traction followed by hip spica.	*5 years later.* Full function, slight aching on prolonged exertion. Not examined personally, but family physician said there is no shortening or atrophy. Roentgenogram shows cyst still present and poorly walled off, but there is a good strong shaft.
A. F.	M	13	Humerus, upper end.	Fracture.	Immobilization in plaster.	*10 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst still visible, but well walled off with good bone strength.
A. D.	M	7	Humerus, upper end.	Fracture.	Immobilization in plaster.	*8 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst almost completely obliterated.
C. S.	F	10	Humerus, upper end.	Fracture.	Immobilization in plaster. Union obtained, but cyst continued to increase in size. Eleven months after fracture, cyst curetted and bone slivers from tibia added.	*15 months later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst filling in well and bone strength good.
G. S.	M	13	Humerus, upper end.	Fracture.	Immobilization in plaster.	*6 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst completely obliterated.

F. F.	M	13	Femur, upper end.	Fracture.	Traction followed by hip spica.	*7 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst small and well walled off. Good bone strength.
R. D.	M	7	Humerus, upper end.	Fracture on 3 occasions in 2 years.	Union obtained each time on immobilization in plaster, but cyst persisted. Patient refused operation at first. Cyst finally curetted out and wall crushed.	*5 years later.* No complaints, no shortening, one inch atrophy in upper arm. Full function. Roentgenogram shows a small cyst well walled off with good bone strength.
N. S.	M	9	Humerus, upper end.	Fracture on 2 occasions in 3 years.	Union obtained each time on immobilization in plaster, but cyst increased. One year after last fracture, cyst curetted and bone slivers from tibia added.	*18 months later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cystic area almost completely obliterated with good bone strength.
N. W.	F	6	Humerus, upper end.	Fracture on 3 occasions in 1 year.	Union obtained each time on immobilization in plaster. Irradiation unsuccessful. Cyst curetted out and wall crushed in.	*3 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows large cystic area still present and rather poorly walled off, but fair bone strength.
E. M.	M	11	Femur, upper end.	Fracture.	Traction followed by hip spica. Cyst remained. Curettage 3 months after fracture.	*12 years later.* No complaints, no shortening, one half of an inch of atrophy, full function. Roentgenogram shows cyst almost completely obliterated.
G. S.	M		Humerus, upper end.	Repeated fracture.	Union obtained each time on immobilization, but cyst remained. Curetted out and walls crushed in. Increased in size again. Curettage and bone slivers from tibia 4 months after first operation.	*16 months later.* No complaints, no shortening or atrophy. Full function. Repeated roentgenograms show large cystic areas still present, but these are becoming progressively more walled off with increasing bone strength, and ultimate prognosis seems good.

membrane. Giant cells are common in the lining wall of the cyst. Geschickter and Copeland have described an acute form of bone cyst in which giant cells are so numerous that the lesion resembles a giant-cell tumor.

The etiology of localized fibrocystic disease is still debatable. Its similarity to the regional form suggests that a single congenital defect may be the cause.

Lang believed that the cyst has its origin in a small hemorrhage due to the occurrence of some minor trauma at the epiphyseal line. Osmotic tension subsequently produced a local increase in pressure with resultant atrophy of the adjacent bone. This would not hold true in a fracture in which the periosteum had been broken, and a repair process had been set up that would result in complete healing of the lesion. Konjetzny has since reported a bone cyst following fracture of the femur, and Zenker has reported a similar occurrence after fracture of a rib.

Geschickter and Copeland have suggested that the solitary bone cyst is a healing or healed giant-cell tumor. This seems unlikely, since the giant-cell tumor occurs in an older age group and is on the epiphyseal rather than the metaphyseal side of the epiphyseal line.

TREATMENT

A wide variety of treatment has been accorded to the solitary bone cyst. Adams, following an earlier paper by Elmslie, described spontaneous healing of a bone cyst after fracture. He believed that most of these cases could be cured by immobilization. In addition, localized fibrocystic disease has been treated by curettage of the cyst with or without crushing of its walls, curettage plus bone grafts, excision of the whole cystic area and a massive bone graft, and by irradiation.

Alldredge has recently reported the results of treatment in a large series of solitary bone cysts collected from several centers. He has found that there are no excellent results, as judged by function and by roentgenographic examination, in cases treated for fracture alone. The results with curettage and packing the cavity with bone grafts are better than with curettage only. He believes that curettage and packing should be used in cysts close to the epiphyseal line, and that cysts well away from the epiphyseal line more often should be subjected to resection and massive bone graft. Malignant changes occurred in two of his patients, both of whom had previously had irradiation.

The purpose of this report is to present a series of twenty-seven cases of localized osteitis fibrosa cystica, dealt with at the Hospital for Sick Children in Toronto during the past fifteen years. Of these patients, twenty-six have been traced until the present time, and twenty-four have had recent physical and roentgenographic examinations. An attempt has been made to estimate the value of the various forms of treatment. Regional fibrocystic disease has been excluded.

In this group of cases, fracture was the presenting symptom in

FIG. 1-A

FIG. 1-B

FIG. 1-C

Fig. 1-A: Roentgenogram showing a fracture through a solitary bone cyst at the upper end of the right humerus. This was treated by immobilization in a plaster spica for three months.
Fig. 1-B: Same humerus six months after the fracture. The cystic area is filling in well.
Fig. 1-C: Same humerus six years later shows a slight increase in density, now well away from the epiphyseal line. This is the optimum result in treatment for the fracture only, but cannot be relied upon.

TABLE II

CASES TREATED BY CURETTAGE AS THE FIRST PROCEDURE

Name	Sex	Age (*Years*)	Site	Symptoms	Treatment	Result
M. C.	F	10	Ulna, upper end.	Pain 8 months, swelling 4 months.	Curettage of cyst.	*11 years later.* Stiffness, swelling and pain in elbow, worse on exertion. Extension at elbow limited by 30 degrees. Some limitation of pronation and supination. Roentgenogram shows cyst well obliterated, loss of joint space, and roughening of joint surfaces in elbow joint.
V. L.	M	1½	Femur, upper end.	Swelling 3 months, would not walk.	Curettage and crushing of cyst wall.	*4 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows small cystic areas well walled off with good bone strength.
R. H.	M	2½	Clavicle, inner end.	Painful swelling.	Curettage followed by irradiation.	*14 months later.* No complaints, full function. Roentgenogram shows cyst obliterated.
R. H.	M	9	Radius, lower end.	Fracture.	Curettage 2 weeks after fracture.	*9 years later.* No complaints or disability. Roentgenogram 2 months after curettage showed cyst filling in well.
P. L.	F	10	Femur, lower end.	Pain 6 months, swelling one week.	Curettage and crushing of cyst wall.	*15 years later.* No complaints except occasional slight aching pain. No shortening, one and one-half inches of atrophy of thigh. Full function. Roentgenogram shows cyst still visible, but well walled off with good bone strength.
J. G.	M	8	Femur, upper end.	Fracture.	Curettage one month after fracture.	*9 years later.* No complaints, no shortening, one and three-quarter inches of atrophy of thigh. Full function. Roentgenogram shows cystic areas well walled off and bone shaft strong.
J. C.	M	12	Humerus, upper end.	Fracture.	Curettage and crushing of cyst wall 6 weeks after fracture.	*1 year later.* No complaints, full function. Could not be traced further. No roentgenographic examination.

TABLE III

CASES TREATED BY CURETTAGE AND BONE SLIVERS AS THE FIRST PROCEDURE

Name	Sex	Age (*Years*)	Site	Symptoms	Treatment	Result
C. T.	F	8	Calcaneum.	Painful limp one year.	Curettage and bone slivers from tibia.	*7 years later.* Slight aching pain on walking a long distance, full function. Roentgenogram shows cyst obliterated.
C. B.	F	9	Femur, upper end.	Painful limp 3 months.	Curettage and bone slivers from femur.	*11 years later.* No symptoms, no shortening or atrophy noted by patient. Could not come in for examination and roentgenogram.
W. S.	M	8	Femur, upper end.	Fracture.	Curettage and bone slivers from tibia one month after fracture.	*6 years later.* No symptoms, no shortening or atrophy, full function. Roentgenogram shows cyst obliterated and shaft strong.
L. T.	M	13	Femur, upper end.	Painful limp 2 years.	Curettage and bone slivers from tibia.	*2 years later.* No complaints, no shortening, 1 inch of atrophy of thigh, full function. Roentgenogram shows cyst obliterated and shaft strong.
B. Y.	F	13	Fibula, lower end.	Pain and swelling 2 weeks.	Curettage and bone slivers from tibia.	*6 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst obliterated and shaft strong.
G. H.	M	7	Femur, lower end.	Painful limp 2 years.	Curettage and bone slivers from tibia.	*11 years later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst obliterated and shaft strong.
G. M.	M	3	Femur, upper end.	Painful limp 2 years.	Curettage, electrocautery of walls, and bone slivers from tibia.	*7 months later.* No complaints, no shortening or atrophy, full function. Roentgenogram shows cyst almost obliterated and shaft strong.
F. H.	M	9	Tibia, upper end.	Fracture.	Curettage and bone graft from tibia 2 weeks after fracture.	*8 months later.* Slight aching pain at night. No shortening or atrophy, full function. Roentgenogram shows cystic areas still present, but well walled off, and bone strong.

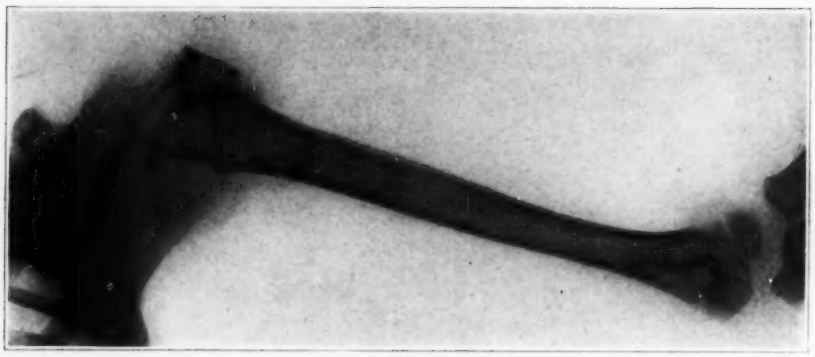

FIG. 2-A

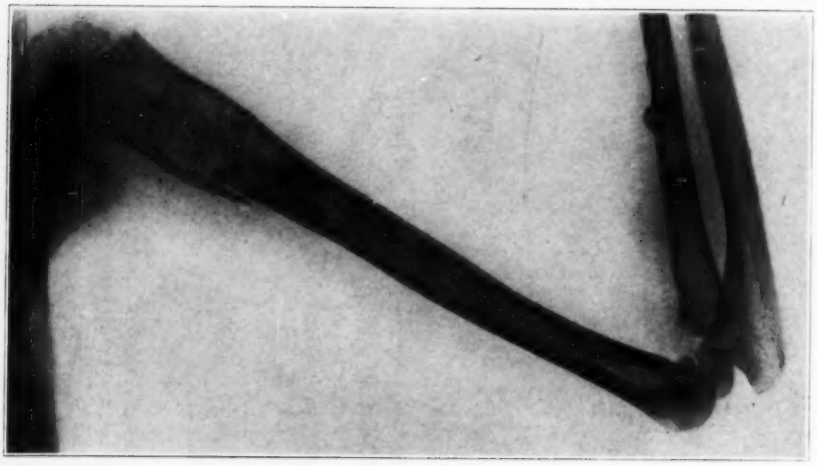

FIG. 2-B

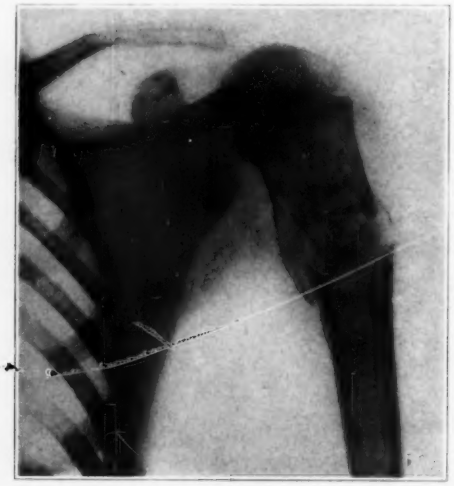

FIG. 2-C

Fig. 2-A: This fracture is one in a series of three occurring in a bone cyst of the upper end of the left humerus within a period of twenty-two months.

Fig. 2-B: The second fracture of the series is shown here. Union occurred each time, but the cyst continued to grow.

Fig. 2-C: Third fracture is shown here. It was followed by a curettage of the bone cyst.

Note, in this series, the shift of the cystic area is away from the epiphyseal line as the bone lengthens.

seventeen cases. Five of the patients in this group were subjected to open operation without a trial with immobilization. In the twelve patients treated by immobilization, all obtained union. Four suffered from repeated fracture, and required operative interference. In two others, the cyst increased in size, and an open operation was done to prevent a further fracture. Thus immobilization gave a satisfactory result in only six out of twelve cases (Table I). In some, cystic areas were still visible many years later, but were well walled off with adequate strength in the shaft of the bone.

Curettage of the cyst, with or without crushing in its walls, was carried out in eleven separate cases either before fracture, soon after fracture, or after an unsatisfactory result with immobilization. Cystic areas persisted, and there was often a considerable time interval before these were well walled off, and local bone strength, as judged by roentgenographic examination, was equal to that of the remainder of the shaft. A good final result was reached in ten of these patients. In one patient, the cyst began to enlarge again, and it was necessary to do a second curettement, this time with the addition of bone slivers.

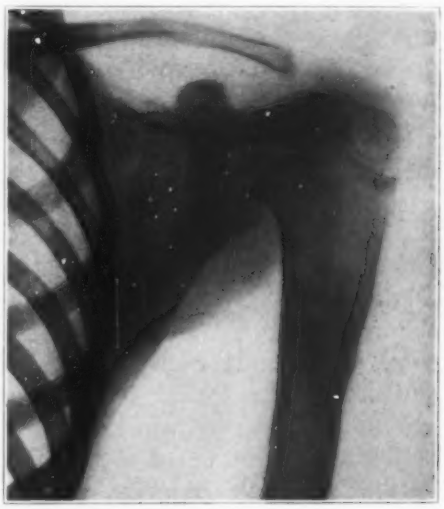

Fig. 2-D

Fig. 2-D: This roentgenogram, taken five months after the curettage operation, shows that the cyst is filling in well.

Fig. 2-E: In this roentgenogram, taken five years later, a definite cyst still remains, but it is well walled off and the bone shaft is strong.

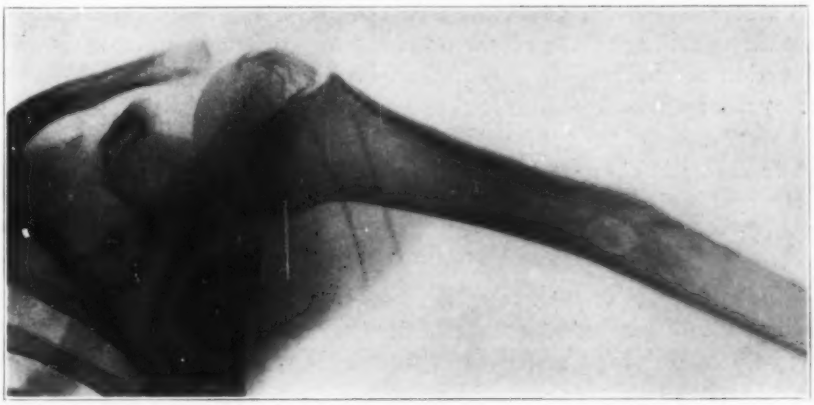

FIG. 2-E

Curettage and packing the cavity with bone slivers was done in eleven different patients, including the one mentioned above in which curettement alone had not been satisfactory. In this one case, a large cystic area still remained eighteen months after operation. Successive roentgenographic examinations showed that this was becoming more walled off, and that the shaft of the bone was increasing in strength as time went on; function was normal and the prognosis seemed good. In the remaining patients, bone was laid down more rapidly than with curettage alone. There was much less residual cystic disease, and bone strength was soon equal to or greater than that of the remainder of the shaft.

Irradiation was used in only two instances. No beneficial effects were noted; but this number is too small to warrant conclusions. Jaffe and Lichtenstein have reported that radiation therapy does not heal solitary bone cysts.

RESULTS

Time seemed a most important factor in the final result. Cystic areas persistent after fracture or operation usually became progressively more walled off, and bone strength increased over the years. Many patients, in whom refracture appeared likely in the early stages, eventually reached a very satisfactory final condition. The cystic process seemed self-limited, with an early stage in which extension was the key note, and a later period in which the surrounding zone of fibrosing osteitis gained the upper hand. There was a marked variation in the viability of the cystic process, but finally all the cases in this series became inactive. The end results were excellent with one exception. A few patients complained of mild aching pain on prolonged exertion, but this did not limit their activities. There was no demonstrable shortening in any case, and no angulation because of uneven growth at an epiphyseal line. While slight muscle atrophy was common, it was not sufficient to prevent full function. The one poor result was in a cyst of the proximal end of the ulna treated by curettage. When seen eleven years later, the patient complained of pain and swelling at the elbow on exertion, and there was considerable limitation of movement. Roentgenographic examination revealed that the cyst was almost obliterated, but that there was loss of joint space and roughening of the joint surfaces in the elbow. The disability seemed due to arthritic changes in the elbow joint, rather than to a persistence of the cyst.

DISCUSSION

Since the solitary bone cyst is definitely non-malignant, it would be fortunate if resolution or satisfactory walling off of the cyst could be relied upon, following a fracture through its wall. As this is not so, it was hoped that roentgenographic examination at the time of fracture would be able to pick out those cysts which could not be controlled

FIG. 3-A

FIG. 3-B

FIG. 3-C

Fig. 3-A: The bone cyst of the lower end of the right femur, shown here, caused local symptoms. It was treated by curetting out the cyst and crushing in its walls.
Fig. 3-B: Roentgenograms, taken four months after the operation, show that the cystic area is filling in.
Fig. 3-C: Roentgenogram taken fifteen years later reveals cystic areas that are still visible, but the bone shaft is strong.

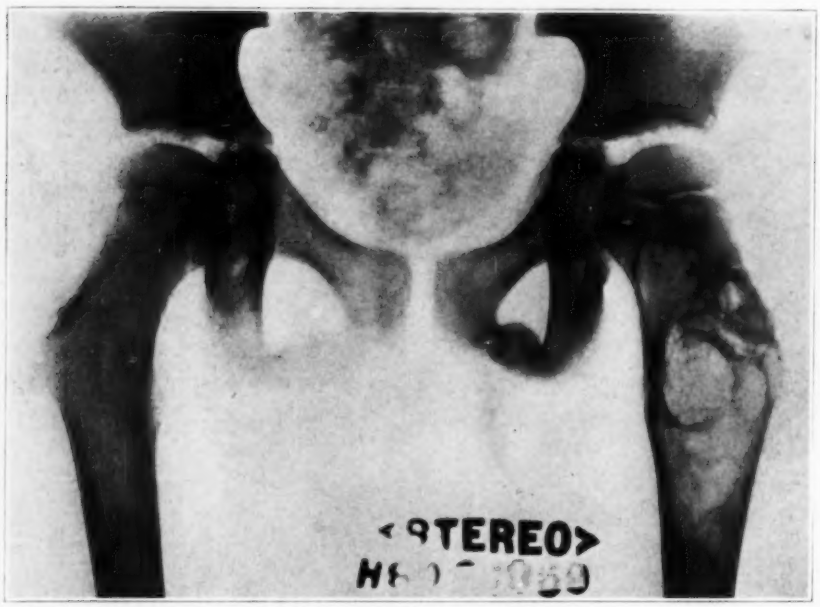

FIG. 4-A

The bone cyst shown in this roentgenogram of the upper end of the left femur produced local symptoms. It was curetted out and the cavity was packed with bone slivers from the tibia.

FIG. 4-B

This roentgenogram, taken two months after the curettage operation, shows that the sliver grafts are still visible, but the cyst is filling in.

by fracture. It seemed plausible that, if there were merely a crack in the wall, then sufficient osteogenesis would not be initiated. This did not hold true in this series of cases, since certain cysts with a minor fracture were obliterated; while in others, with a complete break and some separation of the fragments, the cyst continued to grow. Again, some cysts recurred repeatedly after fracture, and it was in cysts of this type that curettage and crushing of the cyst wall proved insufficient. This suggested that the activity of the cystic process, rather than the severity of the fracture, determined healing. It was then hoped that the activity of the process could be estimated from its translucency and the thinness of the surrounding zone of fibrosing osteitis. This was very suggestive in some instances, but was not accurate enough to be relied upon. The final conclusion was that trial alone could determine if the cyst were curable by fracture. Since a satisfactory result was reached in only half of these patients with fractures treated by immobilization, open operation as the first procedure seemed the surest way to deal with the cyst, and to avoid the prolonged period of fixation necessary if operation were carried out after a failure with immobilization. The open operation can be done within a few days after fracture, or, in complete fractures, at the end of three or four weeks, when enough union has taken place to fix the fragments. The condition of the individual patient determines the procedure to be followed.

FIG. 4-C

Roentgenogram taken eleven years later shows that the cystic area is completely obliterated and that the bone shaft is very strong.

This illustrates the advantage of bone grafts in addition to curettage.

It seemed logical to assume that any cyst which was causing pain or a limp was in an active phase and would increase in size or would be prone to produce a fracture unless operated upon. Conversely, a cyst discovered accidentally, which was causing no symptoms and was well walled off, would not warrant interference.

Curettage and packing the cavity with bone slivers was more satisfactory than curettage and crushing in of the cyst walls. The bone slivers presumably acted as a framework along which osteogenesis could proceed to all parts of the cyst. The cavity should be opened through a good-sized window in its wall, and the contents and lining membrane should be scraped out very thoroughly. Since recurrence was most

common at either end of the original cyst, it is important to work well along the shaft in both directions, with due respect to the epiphyseal line, and to use a window large enough to make this feasible. Cautery was used in only one case, and does not seem to be necessary. The sliver grafts can be obtained from the anterior aspect of the tibia. In patients as young as those in this series, slender slivers several inches in length can be turned up with a gouge and a mallet. This will allow a uniform packing of the cavity with minimal loss of strength in the tibia. In cysts of the femur, grafts can be obtained from the femur itself by extending the incision.

Alldredge has suggested that total excision of the cystic section of bone and replacement with a massive bone graft should probably be done more often in those bone cysts which are at a distance from the epiphyseal line. The less radical operation of curettage and packing the cavity with bone slivers has been satisfactory in this series.

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EXPERIMENTAL STAPHYLOCOCCAEMIA AND HEMATOGENOUS OSTEOMYELITIS * †

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The chief purpose of this study was to produce an acute staphylococcic hematogenous osteomyelitis, which would be practical for experimental study. Since hematogenous osteomyelitis was the goal, staphylococcaemia was naturally a prerequisite.

Many investigators of the past have failed in their attempts to produce experimental osteomyelitis, others have been successful, but their success has been in the nature of a "stunt" with little practical value. Two main difficulties have always barred the way,—first, keeping the experimental animal alive, and, second, obtaining localization of the infection in bone.

In 1885 Rodet produced hematogenous osteomyelitis in experimental animals by intravenous inoculation of staphylococci. Later Lexer used the same method, but found that he could prolong life by the administration of small measured doses of organisms. Among the more successful results are those of Shioda, and Thompson and Dubos. The former inoculated 101 rabbits with intravenous doses of staphylococci and obtained bone abscesses in 22 or 23 per cent. of the cases. However, no rabbit was permitted to live over ninety-six hours, and practically all lesions were found by microscopic study. The latter obtained bone abscesses in eighteen (58 per cent.) of thirty-one rabbits inoculated. However, most of these rabbits were immunized before inoculation in order to prolong life. Immunization would seem to nullify their value for many types of experimental investigation. The authors, therefore, decided to use Lexer's method of measured dosage as it seemed the most practical.

The animals used were chinchilla rabbits, all secured from one source. In preliminary studies by the trial-and-error method, it was found that the rabbit best suited was six to eight weeks of age, and of about 500 to 750 grams in weight. Rabbits of this age were very small, but had excellent epiphyseal lines and were at about the same stage of physical development as a child in the "osteomyelitis age". Efforts to produce hematogenous osteomyelitis in adult rabbits met with complete failure, though suppurative arthritis was common. Scarification of bone with a needle, striking a leg smartly with an iron rod, and similar methods were used in attempts to

* This work was financed by a grant from the United States Public Health Service through the Kansas State Board of Health.

† Read before the Forum on Fundamental Sciences at the American College of Surgeons, Boston, Massachusetts, November 9, 1941.

TABLE I

FREQUENCY OF ABSCESS FORMATION IN CONTROL RABBITS

Group	No.	Bone Abscess		Joint Abscess		Visceral Abscess		Average No. of Days Survived*
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	
Group 1	52	16	30.8	20	38.5	36	69.2	13.5
Group 2	34	17	50.0	18	52.9	19	55.9	14.1
Total	86	33	38.3	38	44.2	55	64.0	13.7

* The longest survival was forty-four days. Two rabbits were sacrificed at thirty-seven days.

cause localization of the infection, but none were successful; so all attempts at localization were abandoned.

The organism used was a hemolytic staphylococcus aureus, secured from a case of acute hematogenous osteomyelitis in a seven-year-old boy. This organism was an excellent toxin producer in the laboratory. It was preserved in a dry state. Fresh cultures of twenty-four-hour broth were used for intravenous inoculation of the rabbits. Purely by the trial-and-error method in preliminary studies, it was found that 0.02 cubic centimeters of the broth culture just described gave the best results as to the length of life of the experimental animal and the formation of abscesses. Blood cultures done within a few days after inoculation were uniformly positive for a staphylococcus aureus, and all abscesses that were cultured yielded the same organism in pure culture. These checks, with the same results, were repeated from time to time throughout the experiment. Other blood studies were done, but it was found that great care had to be exercised not to withdraw too much blood from these small rabbits, as early death was certain to occur. Therefore, it was not practical to carry out all blood studies desired on a single rabbit, nor to repeat those requiring several cubic centimeters of blood too often.

After the above preliminary studies, which involved sixty rabbits, 205 rabbits were inoculated intravenously with the predetermined dose of organisms. These 205 rabbits form the basis for the statistical report. All either died or were sacrificed; all had careful autopsies performed; and all lesions reported are gross ones. Microscopic sections were made of pathological material, but these have not yet been studied sufficiently and will be detailed in a later report. No roentgenograms were made.

Table I indicates the frequency of osteomyelitis (bone abscesses), joint, and visceral abscesses, and the average length of survival in a control group of eighty-six rabbits. Those in Group 1 were inoculated about three months previous to those in Group 2, and, though the same technique was used in each group, it will be noted that there is a fairly wide variation in the percentage of bone, joint, and visceral abscesses. A variation of 19.2 per cent. in the incidence of osteomyelitis is quite wide; how-

ever, rabbits are very unstable animals, and this variation is considered to be within the limits of normal. This is pertinent evidence of the fallacy of attempts to draw conclusions from a small series of cases. A 38-per-cent. incidence of gross osteomyelitis in the entire series is quite satisfactory, and it will be noted that the span of life in most instances was sufficient to permit experimental studies.

Table II presents the results of sulfonamide, antitoxin, and blood-transfusion therapy. The second control group is used in comparison, rather than the entire group, because the experiment in this group was run concurrently with that of the rabbits receiving therapy. Sodium sulfathiazole was administered intravenously in a 5-per-cent. solution of sterile water. The amount of the drug given was 1.5 to 2.0 grains (.065 to .130 gram) per pound per day. In twenty-one rabbits the first dose was given twenty-four hours after inoculation and one daily dose thereafter for a total of ten days. The remaining twenty-one rabbits were given the same amount of the drug, divided into two daily doses. Therapy was started forty-eight hours before inoculation, and the fifth dose of the drug was given through the same needle and immediately after inoculation. Medication was continued for a total of ten days after the organisms were administered. These two groups are reported as one, since there was no significant difference in the results. Blood levels in those animals that received one daily injection were found to be from five to thirteen milligrams per 100 cubic centimeters one and one-half hours after injection, and from zero to a trace at the end of twenty-four hours, while the initial blood level was not so great in the second group, yet there was from a trace to two milligrams per 100 cubic centimeters at the end of twelve hours. It will be noted that the incidence of abscesses is very similar

TABLE II

RESULTS OF THERAPY

Therapy	No.	Bone Abscess		Joint Abscess		Visceral Abscess		Average No. of Days Survived
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	
Control (Group 2)	34	17	50.0	18	52.9	19	55.9	14.1
Sodium sulfathiazole	42	23	54.8	26	61.9	27	64.3	19.1 (L70–2S38)
Sodium sulfathiazole and staphylococcus antitoxin	10	7	70.0	6	60.0	6	60.0	17.4 (L38–1S38)
Staphylococcus antitoxin	30	11	36.7	15	50.0	18	60.0	21.5 (L75–2S38)
Sulfadiazine	13	1	7.7	2	15.4	2	15.4	19.4 (L44–2S44)
Blood transfusions	24	5	20.8	10	41.7	13	54.2	28.2 (L66)

TABLE III

FREQUENCY OF ABSCESS FORMATION IN ALL RABBITS

Group	No.	Bone Abscess		Joint Abscess		Visceral Abscess		Average No. of Days Survived
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	
Control	86	33	38.3	38	44.2	55	63.9	13.7
Rabbits receiving therapy	119	47	40.2	59	50.8	66	56.3	21.4
Total	205	80	39	97	47.3	121	59	18.1

to the control group, but that the average length of survival is appreciably greater. One rabbit lived seventy days and two were sacrificed at thirty-eight days.

Sodium sulfathiazole and staphylococcus antitoxin were given to ten rabbits. The antitoxin was given in ten daily doses of 1000 units each, and the sulfathiazole in ten daily intravenous doses in the amount previously indicated. All therapy was started twenty-four hours after the administration of the organisms. A particularly high incidence of osteomyelitis will be noted, and the average length of survival is not quite so good as under other types of therapy. This group is too small to warrant placing undue emphasis on the results.

Staphylococcus antitoxin was given in 1000-unit intravenous doses to thirty rabbits. Half of these received two daily doses for two days before inoculation, and all received daily doses for ten days after inoculation. There was no particular difference in the results of the two groups and they are, therefore, reported as one. The production of abscesses was quite similar to other groups, but the span of life was greater than under chemotherapy. One rabbit lived seventy-five days and two were sacrificed at thirty-eight days. This was the only group that did not show loss of weight.

Sulfadiazine was given by mouth to thirteen rabbits in daily doses of two grains (.2 grams) per pound of body weight per day. A very small percentage of lesions were obtained and the length of survival was good. However, with only thirteen animals in this series, too much importance must not be placed on the results.

Twenty-four rabbits were treated with blood transfusions. The normal amount of hemoglobin was found to be 13 to 14 grams per 100 cubic centimeters. When this reading fell to 9 grams per 100 cubic centimeters, a transfusion of five cubic centimeters of citrated blood was administered. These animals received from one to six transfusions each. It will be noted that the number of abscesses in this group was less than in the control group, and that the span of life was greater than in any other type of therapy.

Table III is a summary of the entire series of 205 rabbits. It will be noticed that there is no significant difference in the incidence of abscesses in the controls, as compared to those under all types of therapy. As a matter of fact, the comparative averages are remarkably close except for the span of life, and here the rabbits receiving therapy show definite superiority. The incidence of osteomyelitis for the entire group was 39 per cent., which, in the light of the experience of others, is considered quite satisfactory.

Numerous blood studies were made. Due to the small size of the animal, as previously mentioned, great care had to be taken not to withdraw too much blood. Routine leukocyte counts were done on 151 rabbits with no significant findings. Hemoglobin determinations were done on 160 rabbits, and, without exception, there was a steady fall in the amount. The ratio of immature to mature neutrophils (Schilling count) was determined in 124 rabbits. These counts were done three times a week during the life of the rabbit. In not a single instance was there a shift to the left (immature forms). The greatest number of immature cells in any one count never reached 25 per cent. of the total. This finding is contrary to the observations of Joyner and Smith. These investigators demonstrated a shift to the immature side of neutrophils in rabbits inoculated with staphylotoxin, and used this test as a qualitative one for toxicity, and as a guide for antitoxin therapy in cases of acute hematogenous osteomyelitis. The animals in this study were not given staphylotoxin, yet they all had staphylococcaemia and 39 per cent. had acute hematogenous osteomyelitis. Necropsies revealed that many suffered toxic degeneration of visceral organs, yet no shift to the left was demonstrated. The senior author's clinical experience is that a shift to the left of the Schilling count is not uncommon in acute hematogenous osteomyelitis in man, but that it is not a reliable index of the toxicity of the patient nor a guide to antitoxin therapy. The authors have no explanation for this apparent discrepancy in the behavior of man and rabbits to staphylococcus toxin.

Weekly antihemolysin titers were run on sixty-six rabbits picked at random from all groups except those that received commercial staphylo-

TABLE IV

ANTIHEMOLYSIN STUDIES

Group	No.	Bone Abscess		Joint Abscess		Average No. of Days Survived
		No.	Per Cent.	No.	Per Cent.	
Control	86	33	38.3	38	44.2	13.7
Antitoxin therapy	30	11	36.7	15	50.0	21.5
Natural antihemolysin	21*	11	52.4	16	76.2	31.8

* Antihemolysin titers were run on sixty-six rabbits, in whom natural antihemolysin appeared in twenty-one.

TABLE V

DISTRIBUTION OF ABSCESSES IN THE EIGHTY RABBITS WITH BONE ABSCESSES

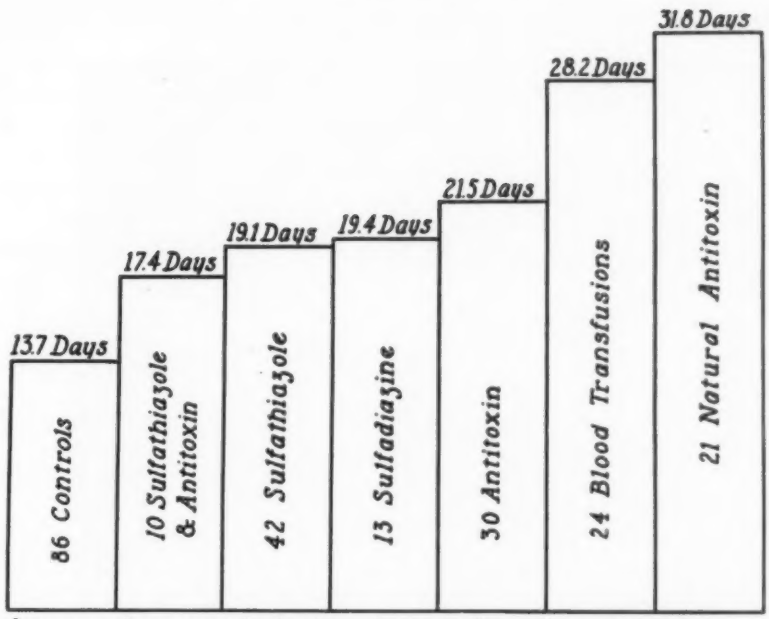
Femur	42
Humerus	39
Pelvis	35
Tibia	13
Vertebrae	8
Ribs	3
Scapula	3
Radius	2
Fibula	1
Sternum	1
Total	147

coccus antitoxin. Natural antihemolysin as high as three international units appeared in the blood of twenty-one (32 per cent.). In a like number of human cases of acute hematogenous osteomyelitis in the senior author's practice, 75 per cent. produced natural antihemolysin. These figures are not comparative, since not all of the sixty-six rabbits had osteomyelitis, but when the animals are eliminated which had staphylococcaemia without gross osteomyelitis, then the percentage is about the same. Natural antihemolysin appeared in the blood stream of the rabbit on about the tenth to the twelfth day of illness. Antihemolysin titers were done on 106 of these rabbits previous to inoculation with staphylococci. None of these animals had an initial titer of antihemolysin. In a previous experiment with over 200 rabbits it was found that not infrequently adult rabbits had a fraction of a unit of natural hemolysin circulating in the blood stream.

Staphylococcus agglutination titers were run biweekly on forty-two rabbits chosen from all groups. A rise in titer was a constant finding, but this apparently had no significance so far as the clinical course of the disease was concerned. The highest titer found was 1 to 2480.

The staphylococcal bactericidal power of serum was measured biweekly in thirty-four rabbits picked from all groups. The method of Spink's was used for this test, and a hodge podge of results was obtained that had no near or remote connection with the clinical cause of the illness.

In Table IV, the group of rabbits that produced their own antihemolysin (antitoxin) is compared with the control group and with those to which commercial antitoxin was administered. Attention is called to the higher percentage of bone and joint lesions, and the greater longevity in those rabbits which produced antihemolysin. While the difference in the number of abscesses is not marked, when one considers normal variations, yet the span of life is very definitely greater and of probable significance. It is quite in line that animals which have more immune response or resistance should live longer. The question may be raised whether there are more bone and joint lesions because these animals lived longer or



Average days survival, after inoculation, of control and various other groups.

FIG. 1

whether they lived longer because of the bone and joint abscesses. From the data gathered in this study, it is impossible to say. However, in man, those patients with staphylococcaemia and no localization in bone are very poor antihemolysin producers and the mortality is high. Those patients with staphylococcaemia that localizes in bone (acute osteomyelitis) are much better antihemolysin producers, and the death rate is relatively low. It is the authors' opinion that stimulation of the bone marrow by infection may have something to do with the production of antihemolysin, and other experimental studies [8] lend some credence to this view, but this work neither supports nor detracts from this theory.

The average span of life of the various groups is depicted in Figure 1. It would seem that natural resistance is most desirable, and that the best therapeutic weapon employed in this study was blood transfusion.

There were 147 macroscopic bone abscesses found in eighty rabbits. No doubt some bone lesions were overlooked in the sectioning of bone, and, therewith, microscopic examination might add materially to this number. About 80 per cent. of these occurred in the metaphysis, only two or three in the diaphysis, and the remainder in the epiphysis. The frequency of occurrence in various bones is shown in Table V. This is quite similar to the occurrence in man, with the exception of the relatively large number in the bones of the pelvis, and the small number in the tibia. Typical bone abscesses from this study are shown in Figures 2, 3, and 4.

The distribution and frequency of occurrence of visceral abscesses is

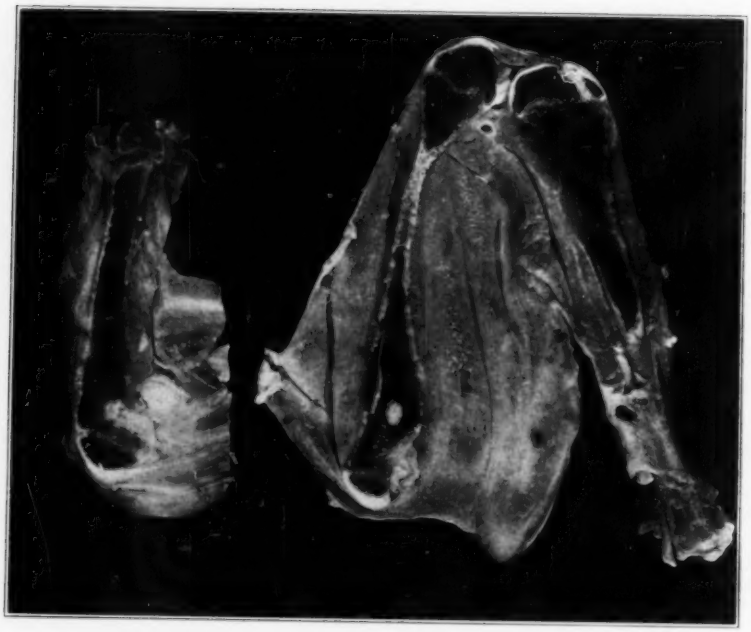


Fig. 3

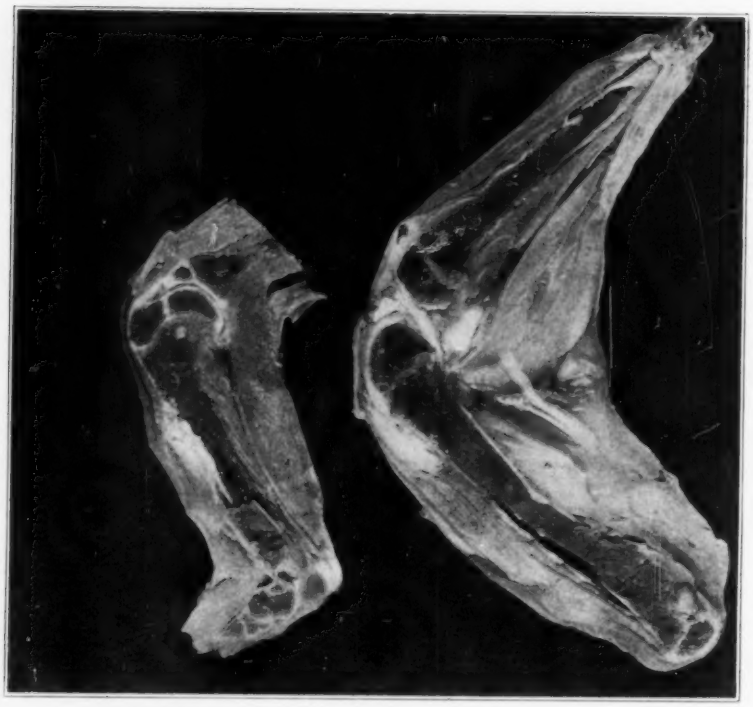


Fig. 2

Typical bone abscesses.

depicted in Table VI. It is noteworthy that liver abscesses were numerous, while the lungs were infrequently affected. The opposite is true in man.

FIG. 4
Typical bone abscesses.

Numerous complications arose during the study of this problem to hamper the work and cloud the end results. The most troublesome was an enteritis which affected many rabbits throughout the experiment. It was so severe as to cause death in some instances before inoculation and study could be instituted, and, in many instances, was assuredly contributory to death after inoculation. Since the enteritis also affected non-inoculated rabbits, it was certainly not due to staphylococcaemia. The sulfonamides used in this study apparently had no effect on the course of the disease.

Pneumonia was encountered on only two or three occasions. Respiratory diseases were not a factor.

Convulsions were a frequent and interesting phenomenon. It was not uncommon to lift a rabbit out of its cage and to have it promptly go into severe generalized convulsions which frequently resulted in death. Practically all these animals sustained compression fractures of the vertebrae (Table VII), many with compression of the spinal cord. This complication did not occur in rabbits that were not inoculated, so must have had some relation to the infection.

There was no gross evidence of infection of the central nervous system, and a possible explanation may be that there was an increased irritability of the central nervous system due to toxaemia. The authors know of no counterpart to this condition in the human. Since practically one-fourth of the animals were so affected, it is quite evident that longevity was seriously affected. Figure 5 is a photograph of a typical compression fracture with severance of the cord.

Yet another interesting complication was the fairly frequent occurrence of massive hemorrhage (Table VIII). In some cases this was undoubtedly the cause of death. The authors have not seen a like condition in the staphylococcaemia of man, but have seen such hemorrhages in patients suffering from staphylococcus food-poisoning.

TABLE VI

DISTRIBUTION OF PRINCIPAL VISCERAL ABSCESSES

Kidneys	68
Liver	52
Lungs	9
Heart	2
Total	131

TABLE VII

DISTRIBUTION OF VERTEBRAL FRACTURES *

Thoracic	50
Lumbar	20
Sacral	9
Cervical	1
Total	80

* Vertebral fractures occurred in forty-nine rabbits, or 23.9 per cent.

DISCUSSION

Staphylococcaemia was produced in 205 rabbits, with resultant hematogenous osteomyelitis in eighty, or 39 per cent. Many of these animals survived for a sufficient length of time for fairly extensive studies in therapy, immunology, and hematology to be carried out. However, the authors feel that they have been only partially successful in reaching the goal stated in the opening paragraph. Length of life can apparently be adequately controlled, so far as staphylococcaemia is concerned, by measured doses. The method of permitting nature to take its course resulted in the localization of the infection in bone in 39 per cent. of the cases, which is satisfactory, if not ideal. Scheman, Janota, and Lewin have recently reported a small series of cases in which they produced and localized primary osteomyelitis by the injection of sodium morrhuate into bone. This procedure might add materially to the percentage of hematogenous osteomyelitis after intravenous inoculation.

Lack of success was in the field of practicability. The young rabbit it was found necessary to use has such a small blood volume that blood studies of any extent are certain to hasten death. Perhaps because of their youth, these rabbits had so many extraneous infections and complications that interpretation of results with regard to therapy and laboratory procedures must be guarded. The rabbit, because of availability and cost, may be the animal of choice, but certainly a larger and sturdier one would be more advantageous.

The method of sulfonamide therapy leaves much room for improvement. It was found that intravenous sulfathiazole disappeared from the blood stream very rapidly. If and when further work is done, this drug will be given by mouth, a simple procedure in divided doses. Sulfathia-

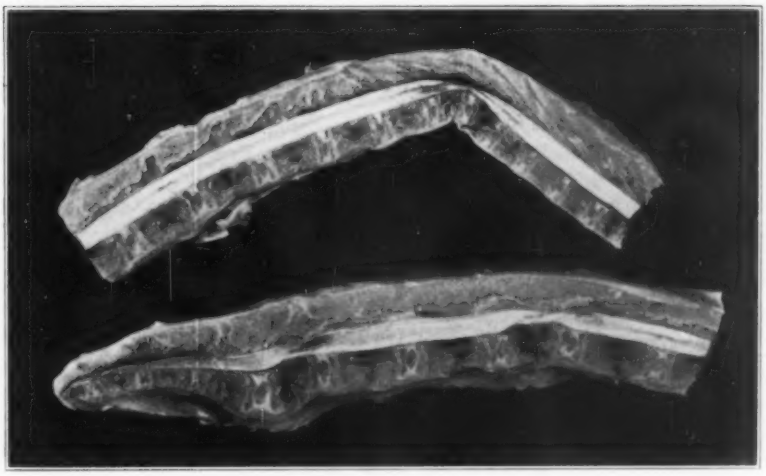


FIG. 5

Typical compression fractures with severance of the cord.

TABLE VIII

DISTRIBUTION OF MASSIVE HEMORRHAGES

Leg Muscle	12
Retroperitoneal	5
Lumbar Muscle	3
Bladder	3
Pleura	2
Brain	1
Lungs	1
Total	27

zole therapy in this experiment appears to be of little value. This is also the authors' clinical experience. However, in consideration of the flaws already mentioned, no positive statements as to the efficiency of this agent can be made.

All these rabbits had non-operative therapy. The results are certainly no recommendation for this type of treatment, yet it is not known whether the results might not have been worse if surgery had been attempted. As a matter of fact, surgery on these small animals is very impracticable if not almost impossible.

This work, then, is presented with no particular claims, but as a record of the authors' experience, which it is hoped will prove beneficial to those in the same line of endeavor.

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PATHOLOGICAL GAIT IN RESIDUAL POLIOMYELITIS *

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This is a preliminary report of a project started before the present emergency developed. Its continuation was postponed because the author was called to active duty with the Armed Forces. It is hoped that at the completion of the War the study may be resumed.

The field of orthopaedic surgery is concerned to a large extent with the problem of studying and improving gait. There is an imperative need for research in this area to make our knowledge of the subject more specific.

Under the term "limp" a layman conveniently categorizes all abnormal movements in walking. These aberrations may be the result of simple disturbances,—such as a pebble in the shoe, ingrown toenail, or a sprained ankle; or, on the other hand, they may be secondary to more serious conditions,—such as, severe shortening of an extremity, slipping of the upper femoral epiphysis, or infantile paralysis. Therefore, gait must always be studied carefully in any patient seen in orthopaedic consultation. Frequently, an experienced clinician may have difficulty in assigning specific reasons for the presence of abnormal gait. The rapid speed at which the motion takes place makes a spontaneous visual analysis of pathological gait difficult. In one second a highly complex, many-jointed, bipedal, neuromusculoskeletal locomotor system, proceeding at the rate of about three miles per hour, traverses a distance of about five feet. Because a double phase of gait is thus completed so quickly, one is left with only a mental image of what has happened. In this investigation moving pictures were studied, frame by frame, thus enabling the author adequately to scrutinize the events.

A review of the literature reveals that students of gait have asked and tried to answer three main questions:

1. How does the moving force operate, or what are the mechanical actions of the various muscles in the dynamics of gait?
2. What happens to what is being moved or what are the pathways of motion of the various components of the human body during gait?
3. What are the pressure and time relations of the base of the locomotor system (sole) to the supporting structure (ground)?

Steindler, in the first chapter of his book, presents a summary of the history of the mechanics of human locomotion from the early Greeks to

* This research was performed under the guidance of Arthur Steindler, M.D., at the State University of Iowa, Iowa City, Iowa, and was sponsored by The National Foundation for Infantile Paralysis, Inc., New York, N. Y., 1939 to 1940.

the present day. Marey, Rudolph Fick, Strasser, Weber and Weber, Braune and Fischer, and Muybridge were among the nineteenth-century workers. Contemporary contributions of Basler, Scherb, Elftman, and Schwartz and his coworkers have also been noteworthy.

The classical work of Braune and Fischer was based on a twelve-year study of a single normal professional subject. A series of Geissler tubes were fastened to various portions of the body, and the intermittent lighting of these was recorded on a photographic plate. The pathways obtained were referred to a three-dimensional coordinated system for mathematical analysis. Today those same studies can be made with a moving-picture camera. In the author's normal cases, the pathways are identical with those of Braune and Fischer.

Braune and Fischer's work was important and fundamental, and serves as a foundation for the even greater complexities of pathological gait. However, the exhaustive mathematical treatment of their data would be extremely difficult to apply to pathological gait, and of questionable value to clinical orthopaedic surgery.

Kozyrev pointed out that visual interpretations alone are not sufficient for a correct analysis. He reported a case of equinus deformity, where the patient's heel seemed to touch the floor during walking, but an electrical contact disclosed that the heel never actually touched the ground. He also reported a case of calcaneus deformity where the opposite situation held true.

At the present time, Schwartz is carrying on some basic work in the field of gait. By means of a brilliantly conceived technique, he obtains quantitative information as to pressure and time intervals in relation to the contact of various portions of the sole of the foot with the ground, the subject either being barefoot or wearing a shoe.

Morton and Elftman have recently perfected a method of visualizing the degree of pressure on the various points of the soles of the foot during walking or standing, in barefooted subjects.

PURPOSE AND TECHNIQUE

The purpose of this study was to record by photography the pathways of motion of the lower extremity in patients with residual infantile paralysis. The abnormal mechanics in relation to specific muscle paralysis was observed, and graphically and photographically portrayed. This partially answers the fundamental question, "What happens to what is being moved?" The answer to the query, "How does the moving force operate?" is partially dealt with by interpolation on the basis of a careful muscle check just prior to the study.

Patients were selected for study, in whom the abnormal factor or factors were known and observable. Every patient was able to walk in bare feet without a brace. One extremity was normal and the other abnormal, so that aberrations could be ascribed to the paralyzed extremity and correlated with the specific muscle deficiency. Most of the patients had

not had any operative procedure performed on the foot. In one particular case, studies were made before and after operation. Such a qualitative analysis of pathological gait, even without mathematical treatment of velocity, acceleration, efficiency, pressure, and angular values, is of distinct advantage in bringing us one step further toward a better understanding of pathological motion of the locomotor apparatus.

The subjects were photographed from a distance of twenty feet with a moving-picture camera equipped with a telescopic lens. A white guide line, one meter long, in the center of the field, aided the patient in walking at right angles to the line of vision of the camera. Circular black dots about one-half of an inch in diameter were marked on the hip, knee, and ankle joints by means of a burnt cork. A photographic speed of thirty-two frames per second furnished a convenient quantum of motion. The moving-picture film was projected frame by frame on large-sized graph paper, and the progressive points plotted represent the forward motion of the hip, knee, ankle, and toe. Owing to a lack of space, only a few cases and figures will be presented.

RESULTS

Case 1. Normal Gait

Figure 1 represents a recording of the pathways of motion of the hip, knee, ankle, and toe in normal gait. Only the right lower extremity which faces the camera is graphically portrayed. As each frame of the picture is projected, the hip, knee, ankle, and toe points are plotted. These points are then joined longitudinally to form a single phase. The time interval between each progressive dot or each phase is one thirty-second of a second. At each critical phase, the joining lines are drawn in boldly, and in the intervening phases they are portrayed by broken lines. The contour of the extremity is also traced at the critical phases.

At the extreme right, the pathways which run transversely as undulating curves are labeled "hip", "knee", "ankle", and "toe" respectively. Running obliquely off the hip pathway above, are key phrases describing the events. The graph begins with "right heel strikes". This is the beginning of "stance", or the period from the time the heel strikes the ground until the toe leaves. "Right heel off" denotes the moment when the heel loses contact with the ground. Of course, before this is visualized, the amount of pressure on the heel is decreasing, and being shifted to the forefoot. "Left heel strikes" refers to events of the opposite extremity, which is not graphically portrayed. This occurs as the right heel is lifted off the ground, but at a time when the right forefoot is still in contact with the ground. It takes about two thirty-seconds of a second in this subject for the toe to strike after the heel establishes contact. The word "toe" is used to denote the entire forefoot region. Actually, the metatarsal arch comes in contact with the ground a fraction of a second before the toes; but, for the purposes of this study, this differentiation is ignored. "Left toe strikes" implies that the forefoot has come

down to the supporting surface. "Swing" signifies that interval between the time the toe leaves the ground and the heel strikes, or the phase between one stance and the next. A "double step" consists of one complete consecutive stance and swing phase. In walking, the duration of stance is always longer than that of the swing; in this particular instance it is approximately eleven thirty-seconds of a second, in contrast to three thirty-seconds of a second. Also, in walking, both feet are never off the ground at the same time. "Double support" is the time during which both feet are in contact with the ground. This extends from "right heel off" and "left heel strikes" to "right toe off" and has a duration of four thirty-seconds of a second in this record. Absolute temporal values vary with the speed of gait. The maximum degree of flexion of the knee

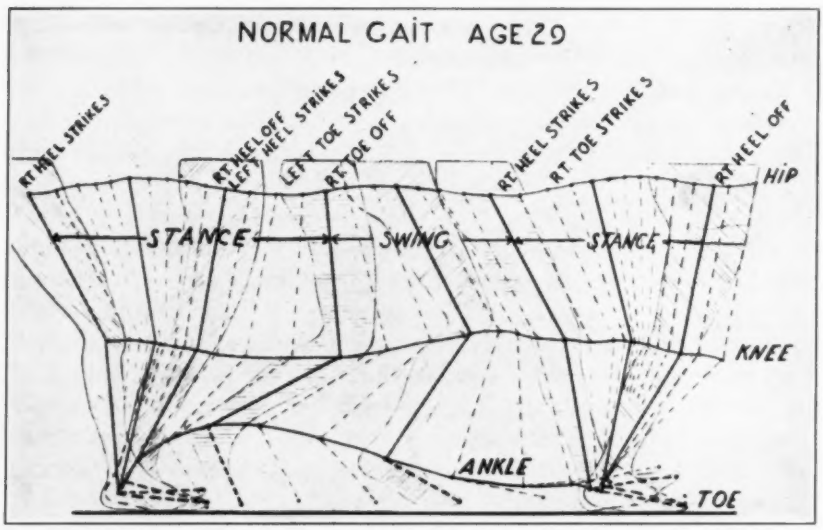

FIG. 1-A

Case 1. Normal gait, showing the undulatory pathways of the hip with two maxima and two minima in a complete double phase. There is flexion of 73 degrees in the knee joint, associated with a corresponding ankle rise in order to clear the ground. The heel strikes first in stance. The speed is slower in stance and more rapid during the swinging phase.

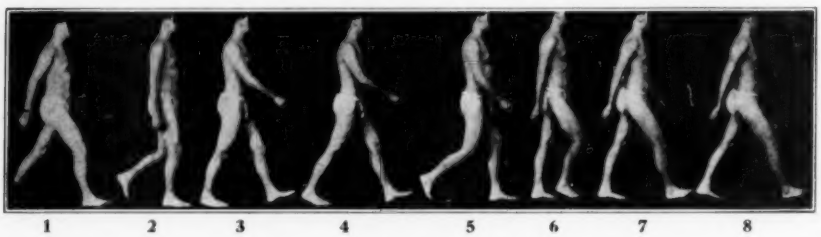

FIG. 1-B

The second picture from the left shows how the knee remains slightly flexed during stance, and, in the next two pictures, how it completely extends in the deploy. The fifth and sixth illustrate the degree of flexion of the knee during the swinging phase.

joint during the swing phase is 73 degrees, when the subject adopts a natural full stride on even terrain. However, about 60 degrees of flexion in the knee joint is sufficient motion for walking on flat ground, without a limp. The amount of flexion employed varies with the speed of gait. A short step at a slow speed necessitates less flexion than a long step at a fast rate. Stair-climbing requires about 90 degrees of knee flexion.

The photographic negative of the moving picture was carefully studied frame by frame. Eight selected frames were projected and photographed (Fig. 1-B). They were then lined up in sequence and rephotographed resulting in a composite strip displaying critical phases of a double phase of gait.

The limb is partially flexed as it is set down. The heel strikes first. The weight is carried along the outer aspect of the foot to the head of the fifth metatarsal, and then across the metatarsal arch to the head of the first metatarsal. When the center of gravity passes beyond the supporting base, body balance is lost. This is immediately regained as the opposite forward-swinging extremity enters stance. Then the partially flexed limb extends and imparts forward propulsion to the body. The "deploy" of the leg is the period of time during which the center of gravity passes gradually from the posterior to the anterior portion of the foot, leaving it at the toes.

The forward swing of the limb is accompanied by a forward motion of the body. The limb has increased length, owing to plantar-flexion of the foot. In order to compensate for this, the hip and the knee flex, enabling the foot to clear the ground. Toward the end of the swinging phase, the knee incompletely extends and the foot dorsiflexes.

The hip pathway (Fig. 1-A), in a double phase of gait, reveals two maxima and two minima. The curve is depressed preparatory to, and in the early phase of stance. It rises in the middle of stance, as the body rotates over the ankle joint. A second depression occurs at the end of stance, and a second rise when the pelvis is elevated in swing.

Although the knee pathway (Fig. 1-A) roughly parallels that of the hip, it differs because of the independent flexion-extension movements of the knee. There is a slight rise during the first half of stance, followed by a long shallow depression, extending into the first half of swing. Then, in the latter half of swing, as the knee begins to extend, and the hip continues to flex, the curve rises, enabling the foot to clear the ground. Once the knee is almost fully extended, the knee pathway dips downward, and the extremity enters stance.

The ankle pathway (Fig. 1-A) rises rapidly in the latter part of stance and the early phase of swing, after which it tapers off. During a double phase, the ankle joint alternately plantar-flexes and dorsiflexes twice. At the beginning of stance, following the impact of the heel, plantar-flexion occurs. It changes to dorsiflexion when the superincumbent body shifts beyond the ankle joint. As deploy occurs, the ankle plantar-flexes. During the latter half of swing, it dorsiflexes, and enters stance in that position.

This detailed review of normal gait serves as a basis of comparison for the eccentricities of pathological gait.

Case 2. Shortening

Shortening of two inches alone, without the presence of muscle paralysis, produces increased rotation in the frontal plane toward the affected side, and is reflected in the profile view by an exaggerated undulatory motion in the hip pathway, and a slight corresponding change in the knee pathway. The effect on the ankle and toe pathways is not detectable on the graphs. In the anterior view, the marked drop of the pelvis on the side of the shortening is quite apparent during stance. There was an accompanying static scoliosis, quite apparent with each step, but this was not studied.

Shortening can be dealt with in several ways. The individual can completely extend the normal leg in deploy, necessitating a "stepping down" on the short extremity; he can allow the normal leg to remain partially flexed at the hip and knee in deploy, producing a relative shortening to match the diminished length of the other extremity; or he can employ a combination of both of these methods. In this particular case the latter was employed.

Case 3. Isolated Paralysis of the Tibialis Anterior

Isolated paralysis of the tibialis anterior, in an eleven-year-old patient who had been wearing a brace, revealed no contractures upon examination, and his gait appeared quite good. However, analysis of the gait recordings discloses that the heel and toe strike the floor almost simultaneously, whereas in the normal record there is an interval of two thirty-seconds of a second between the impact of the heel and that of the forefoot.

Case 4. Equinus with Steppage Gait

In this case of a seven-year-old child, the date of onset of poliomyelitis was not known. A lengthening of the tendo achillis and a capsulotomy were done in April, 1939, because of the presence of a marked equinus deformity. An examination in October, 1939, revealed a marked equinus element in the gait. The leg lengths were equal. The muscle check showed the following findings:

Tibialis anterior	1 Trace
Extensor longus digitorum	2 Poor
Extensor proprius hallucis	0 Zero
Other muscles	X Normal

This patient had a paralysis of the dorsiflexors of the right foot with contracture of the plantar-flexors. Examination of Figure 2-A reveals that, instead of the heel striking the ground first, the forefoot (designated as "toe") makes first contact with the earth at the end of swing and the beginning of stance. This is apparent in the pathway recordings (Fig 2-A) and in the photographs (Fig. 2-B). The heel then approaches the ground,

and either barely touches it or does not make contact with it. Kozyrev has demonstrated that visual interpretations are not reliable in determining whether or not the heel actually makes contact with the ground.

The knee pathway illustrates that increased flexion must occur in the knee and hip for the foot to adequately clear the walking surface. Eighty degrees of knee flexion is required, as compared with 60 degrees in the normal. Views *8* and *9* (Fig. 2-B) demonstrate this fact strikingly.

There is about 45 degrees of equinus deformity as the stance ends and the swing begins, producing a relative increase in the length of the extremity.

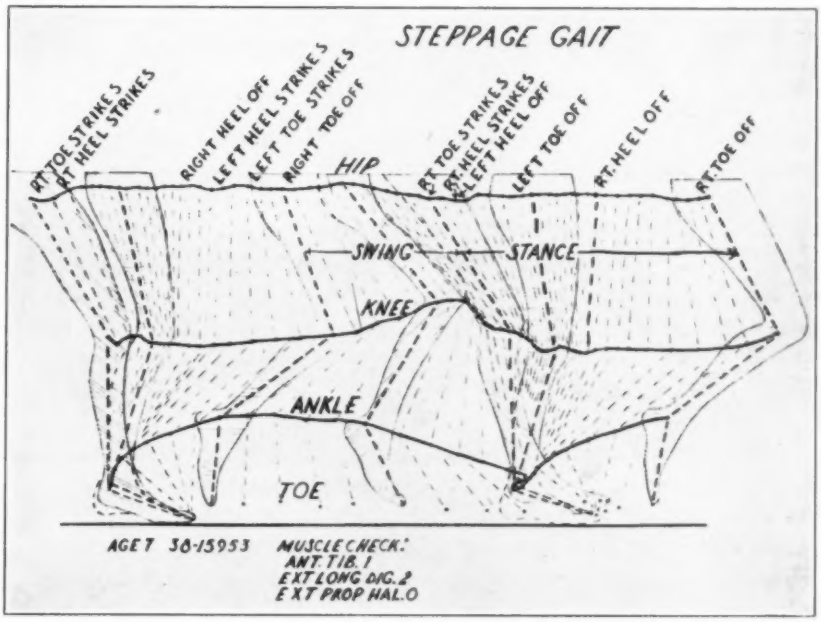

FIG. 2-A

Case 4. In steppage gait the forefoot strikes first, and the heel does not contact the ground in stance; the rebound, reflected in the upward rise of the knee pathway immediately after the forefoot strikes the walking surface, results from the stretch reflex; 80 degrees of flexion of the knee is required during the swinging phase to enable the relatively increased length of the extremity to clear the ground. Note the corresponding increase in the rise of the ankle curve. (Compare with Figs. 1-A and 1-B.)

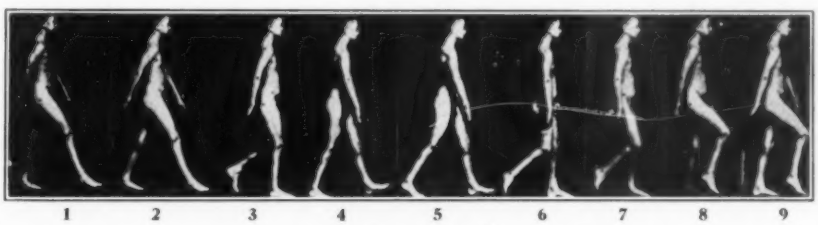

FIG. 2-B

The second picture from the left illustrates how the forefoot strikes the ground before the heel in stance; the sixth, seventh, eighth, and ninth pictures demonstrate the increase in knee flexion.

At the beginning of stance, the knee pathway dips down for the duration of one phase as the heel approaches the ground. This downward impact is followed immediately by rebound, signifying the reaction of the normal triceps surae (stretch reflex).

Case 5. Preoperative Calcaneovalgus

This patient had an acute attack of anterior poliomyelitis at the age of four. Seven years later, examination revealed a residual calcaneovalgus deformity on the left. His right lower extremity was normal, but there was a decided limp on the left. The muscle check revealed:

Gastrocnemius	0 Zero
Tibialis anterior	0 Zero
Tibialis posterior	0 Zero
Peroneus longus	X Normal
Peroneus brevis	X Normal
Extensor digitorum longus	3 Fair
Extensor proprius hallucis	3 Fair
Flexor hallucis longus	4 Good
Flexor digitorum longus pedis	2 Poor
Quadriceps	X Normal
Hamstrings	X Normal
Gluteus medius	2 Poor
Gluteus maximus	4 Good
External rotators	4 Good
Internal rotators	4 Good

There was a calcaneovalgus deformity due to the presence of a complete paralysis of the gastrocnemius, opposed by fair extensor power. The normal peronei, working against completely paralyzed tibiales, produced a valgus deformity, but were not of sufficient strength to compensate for the deficient gastrocnemius. In addition, there was a weak gluteus medius with a corresponding gait defect.

As the lower extremity enters the stance phase (Fig.3-A),* there is a marked degree of calcaneus deformity. One thirty-second of a second after the heel touches the ground, the toe strikes, and the foot goes into valgus. The heel remains in contact with the ground for a much longer time than normal. In the normal gait (Case 1), the duration of heel contact was ten thirty-seconds of a second, and five thirty-seconds of a second later the toe left the ground. This is a ratio of two to one. Contrastingly, in this case, the duration of heel contact was sixteen thirty-seconds of a second; and two thirty-seconds of a second later the toe left the ground making a ratio of eight-one. The peroneus longus and peroneus brevis, even though of normal strength, are not sufficient for adequate plantar-flexion in gait. The foot clears the ground with greater ease, owing to the calcaneus deformity, and, therefore, the ankle pathway does not

* The graph in Figure 3-A portrays the left lower extremity. For purposes of uniformity and ready comparison the negative was reversed, so that the record reads from left to right. Likewise, the extremity facing the camera in Figure 3-B is the left lower extremity.

show the rise in the beginning of the swinging phase as is seen in the normal. Instead, there is only a slight elevation at the beginning of the swinging phase, followed by a plateau until the preparation for stance occurs. Then the foot descends slightly, and the heel comes down to the ground.

The pathway of the knee throughout stance is an arc described by the leg pivoting on the heel as the knee remains fully extended. In normal gait the knee flexes slightly during stance, and then extends again as pressure is applied to the ground at the end of deploy to produce forward propulsion. In this instance the knee remains fully extended for the duration of stance as it pivots over the heel. The second, third, fourth, and fifth pictures in Figure 3-B indicate the latter. In Figure 3-C the marked valgus deformity is apparent.

Postoperative Calcaneovalgus.

Four months later, following an astragalectomy and transplantation of the peroneus longus to the tendo achillis, the patient began walking again and was restudied. He favored the operative site slightly, but still displayed enough improvement to warrant recording his gait. The peroneus transplant was functioning actively.

The record (Fig. 3-D) discloses that the calcaneus deformity has gone and slight plantar-flexion is present. The toe strikes first instead of the heel, thus indicating some overcorrection. The heel hits one thirty-second of a second later. The ankle pathway has been almost entirely restored to normal. Minor fluctuations in the knee and hip pathways during stance are the result of unsteadiness of gait, because of the feeling of insecurity on the foot recently operated upon. The knee flexes slightly during the first phase of stance, and the patient no longer pivots on his heel. The preoperative arclike pathway of the knee in stance is replaced by a normal curve.

The anterior view (Fig. 3-F) discloses that the valgus deformity has been corrected. It also illustrates how the gluteus medius lurch occurs before the weight is shifted to the affected limb, and how the upper extremity is abducted at the same time, as observed by Calvé.

The astragalectomy and peroneus transplantation affected the gait considerably, and improved it in a very specific sense, as indicated by restoration of the normal ankle pathway, slight flexion of the knee in stance, disappearance of heel-pivoting, and a decrease in the duration of heel contact. The gluteus medius gait is still present.

DISCUSSION

Whereas Braune and Fischer employed still photography, and studied motion by means of a heavy contrivance to which Geissler tubes were attached, the author used moving-picture photography, thus eliminating all their cumbersome apparatus. Science has advanced sufficiently so that all that is necessary at this stage is to apply known techniques and equipment in order to obtain accurate and illuminating data.

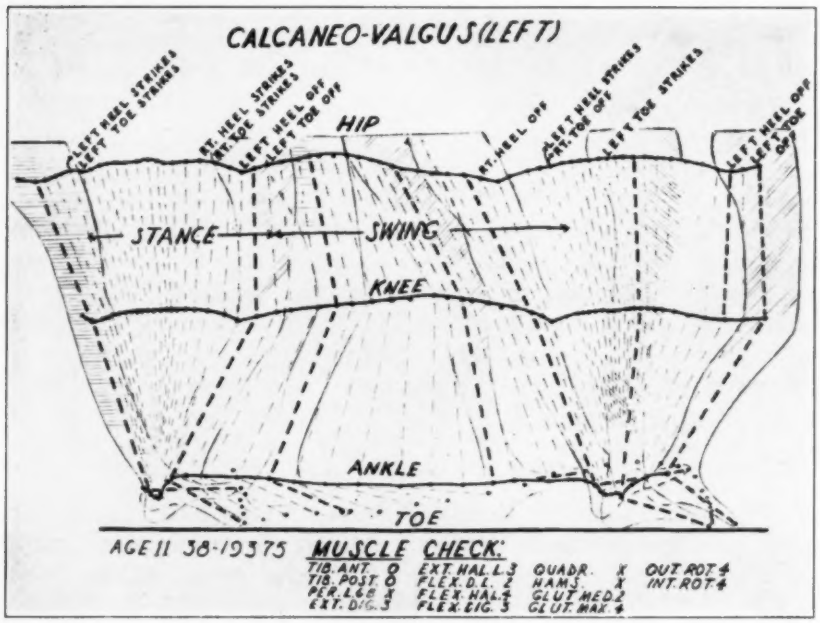

FIG. 3-A

Case 5. The extremity depicted in this and the following illustrations is the left. The films have been reversed so that all graphs read from left to right.

In calcaneovalgus, the knee pivots on the heel in stance. Compare the arclike curve of the knee pathway in stance with the gentle, sloping curve of the normal. (See Fig. 1-A.) The ankle pathway is markedly depressed and flattened, because the calcaneus decreases the relative length of the lower extremity and enables it to clear the ground with ease. The ankle pathway dips downward just prior to the beginning of stance as the heel sets down.

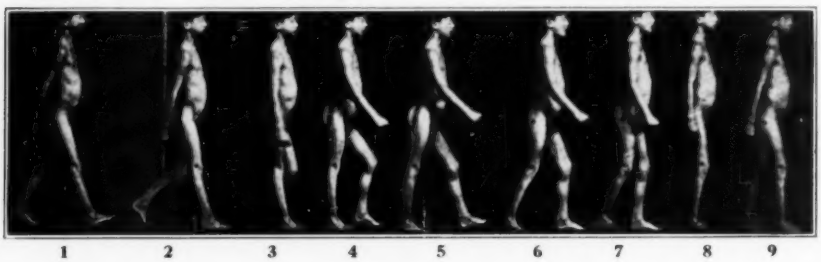

FIG. 3-B

The first picture on the left illustrates the sharp contrast of the heel with the walking surface while the foot is in dorsiflexion. The first five pictures on the left clearly demonstrate how the knee remains in full extension throughout stance. The degree of flexion in the knee and hip are less than normal.

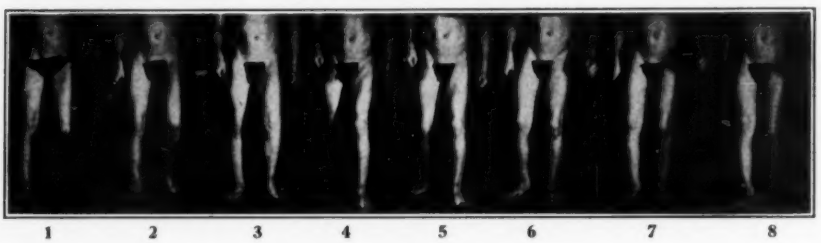

FIG. 3-C

The valgus component of the deformity is clearly discernible in all views.

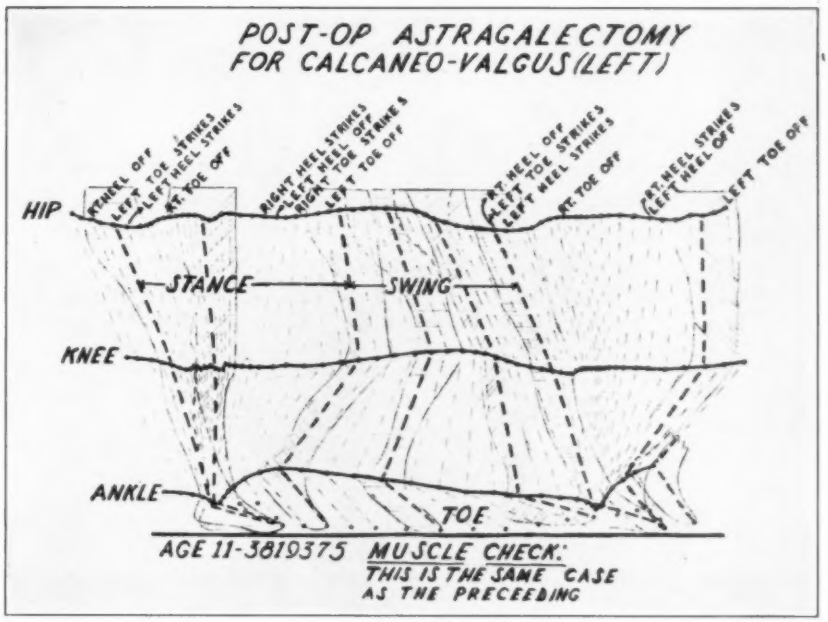

FIG. 3-D

Postoperative studies following astragalectomy for the calcaneovalgus deformity reveal striking improvement of the abnormal components of the pathways of motion. The left forefoot strikes one thirty-second of a second before the heel (slight overcorrection). The ankle curve has a normal contour, and the degree of flexion of the knee has increased. In the stance phase, the oscillating character of the curve is the result of a feeling of insecurity on the foot recently operated upon.

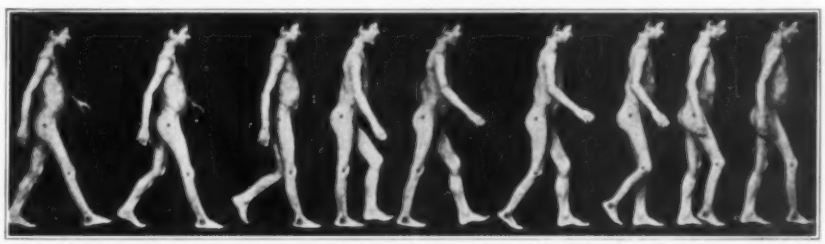

FIG. 3-E

The second picture from the left indicates how the calcaneus deformity has been corrected. The forefoot contacts the ground one thirty-second of a second before the heel (slight overcorrection). The degree of flexion of the hip and knee is increased.

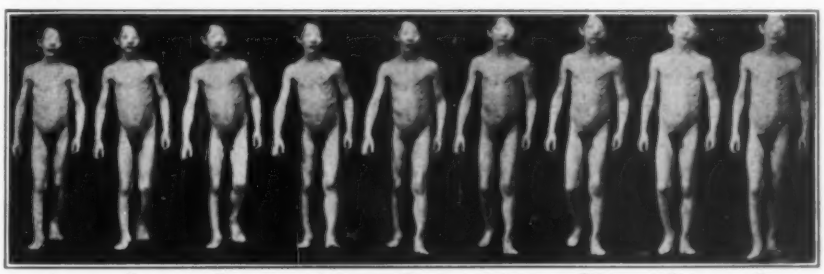

FIG. 3-F

The correction of the valgus element is apparent. The second, third, fourth, and fifth photographs from the left disclose the gluteus medius gait. This is an entirely separate factor in the etiology of the "limp" in this case.

The study of a brief glimpse of gait in a single subject entails a great deal of time and effort. Schwartz has a staff of trained technicians who aid him in performing his intricate and painstaking studies. Thus, it is obvious that adequate scientific investigation of gait requires both a well-equipped laboratory and a group of workers. A synchronized combination of stroboscopic moving pictures; graphite discs for pressure and time recordings from the sole of the foot; and action-current readings to indicate exactly the time and duration of muscle contraction would yield information of inestimable value, and would solve many of the problems before us today.

SUMMARY AND CONCLUSIONS

1. Photographic studies were made of the pathways of motion in the lower extremities of selected cases of residual infantile paralysis.

2. The importance of the technique of this particular investigation was the fact that the patient was not weighted down with cumbersome apparatus, and was not required to walk on a treadmill. Either of the above adds further embarrassment to the gait of a paralyzed individual already operating under reduced efficiency, and the recordings thus obtained do not portray the true state of locomotion.

3. The kinesiological soundness of operative procedures may be scrutinized by this method by means of preoperative and postoperative studies.

4. Shortening of two inches did not fundamentally affect the pathways. It produced some increased rotation in the frontal plane and was reflected in the profile view by an exaggerated undulatory hip pathway, and, to a lesser degree, by a corresponding change in the knee pathway.

5. In equinus deformities, owing to the relative increase in the length of the extremity, a great deal of increased flexion occurred in the knee and hip in order to enable the foot to clear the ground; in stance the forefoot either struck the ground before the heel or simultaneously, depending on the degree of equinus; after the impact of the forefoot some of the patients showed a marked rebound resulting from the stretch reflex.

6. In calcaneus deformities, the heel struck the ground first in stance and remained in contact for a longer time than normal; the ankle and toe pathways were depressed, indicative of the fact that the foot was able to clear the ground with greater ease than the normal; the subjects tended to pivot on the heel with the knee fully extended.

7. An analysis of one case of calcaneovalgus following an astragalectomy and transplantation of the peroneus longus to the tendo achillis revealed striking graphic improvement in the gait consisting of: disappearance of heel pivoting; slight flexion of the knee in stance; decrease in the duration of the heel contact with the ground; normal pattern of the ankle curve; and striking of the forefoot on the ground a moment before the heel in stance (slight overcorrection).

8. This is a preliminary report, but the results indicate very defini-

nitely that additional work in this field would be of great value in clarifying many of the problems of this complex subject.

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INTERNAL FIXATION OF METACARPAL FRACTURES EXCLUSIVE OF THE THUMB

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From the Station Hospital, Camp Lee, Virginia

With the mobilization of a large fighting force, the job of orthopaedic surgeons in the Army is to return various injured soldiers to duty in the best possible condition, and in the shortest space of time. Since internal fixation of fractured bones has become more common and the results more satisfactory, it is only natural that metacarpal fractures should also be subjected to pin fixations. In the Orthopaedic Clinic of Camp Lee, Virginia, the conclusion has been reached that it is safe to treat the majority of simple metacarpal fractures, exclusive of the thumb, by the insertion of one or two Kirschner wires under local anaesthesia one day, and to allow the patient to return to duty the following day.

Twenty cases of fracture of the metacarpal have been treated in the past three months, without a case of infection, and with very gratifying results. The majority of these fractures were simple, or comminuted, involving the distal third or metacarpal neck. The remainder were oblique, involving the mid-shaft, or simple transverse, involving the base. Any of these types of fractures are ideal for the insertion of wires,—single wires in fractures through the neck or base of the metacarpal, and double wires in oblique fractures of the mid-shaft. It has been found that shortening, angulation, or overriding of the fractured fragments, can be corrected and maintained after reduction by this method, and that free use of the entire hand and wrist is provided without the hindrance of casts or splints.

FIG. 1-A

Fracture of the neck of the fifth metacarpal.

Fractures of the metacarpals, together with those of the phalanges, are the most common fractures in the skeletal system, and the authors feel that even

FIG. 1-B

FIG. 1-C

Figs. 1-B and 1-C show the reduction with the pin inserted.

Figs. 1-D and 1-E show the amount of flexion and extension one hour following the pinning.

FIG. 1-D

FIG. 1-E

in private practice, where patients with various vocations are met—such as stenographers, pianists, accountants and bookkeepers, and others whose livelihood is dependent on their hands—this is a method of choice.

The durability of this method is shown in one case in a soldier who had suffered an oblique fracture through the mid-shaft of the fourth metacarpal. Double wires were inserted, and he played basketball three days later with very little discomfort.

With extreme care for good asepsis, these wires may be inserted, in an office, under novocain. The solution is injected into the fracture site and over the point of the wire insertion, and the periosteum is infiltrated. Extreme care and gentleness should be used, for in inexperienced hands damage may be done to the soft tissues. Fortunately the major vessels,

nerves, and tendons lie both palmar and dorsal to the fracture, and no important structures are found between the metacarpals. Fractures

FIG. 2-A

FIG. 2-B

Transverse fracture of the base of the fourth metacarpal, with shortening and displacement, and posterior angulation of the distal fragment.

FIG. 2-C

FIG. 2-D

Figs. 2-C and 2-D show the result following pinning.

involving the neck or distal third of the metacarpals usually result in typical deformities, characterized by the shortening of the length of the bone because of angulation of the fragments. There is a dorsal projection of the proximal fragment and volar disp'acement of the metacarpal head. This typical deformity is the result of the action of the interosseous muscle which is a flexor of the proximal phalanx. The capsule at the metacarpophalangeal joint covers both the metacarpal head and the base of the proximal phalanx. On flexion the capsular attachment draws the distal fragment downward. One may notice the hypermobility of the fifth and fourth metacarpals over the second and third. This is necessary to form the proper anterior arch and cupping of the hand. This finding is used to advantage, for, if fractures of the neck of the fourth or fifth metacarpal are reduced and the shaft is displaced anteriorly or palmad to the maximum amount, and if fixation is carried out, no further angulation can take place.

FIG. 2-E

Three weeks later, showing callus formation and the obliteration of the fracture line.

In pinning the fifth metacarpal with the fracture through the neck, five cubic centimeters of 1-per-cent. novocain is injected into the fracture site, and five cubic centimeters over the lateral surface of the metacarpal, approximately one-half of an inch posterior to the fracture site, making sure the periosteum is well infiltrated. The skin is then punctured with a sterile Kirschner wire under strict asepsis, and the round of the bone is determined, so that the center may be obtained. Once the center of the bone is located, the proximal fragment is depressed toward the palmar surface to the limit of its mobility, and the fracture is reduced with the addition of slight traction. This position tightens the capsule and pulls the distal fragment into position. With an assistant holding the distal fragment in position, the operator then drills the wire through, with the regular drill and guide attached at an angle so as to engage the center of the fourth and third metacarpal bones, although it is not necessary to penetrate the third metacarpal in every case. The wire is cut approximately one-quarter of an inch from the skin margin, and is sealed with collodion. A small cork is applied over the wire tip and is fastened with adhesive (Figs. 1-D and 1-E). Figures 1-B and 1-C show the reduction with the pin inserted. Figures 1-D and 1-E show flexion and extension immediately following the

pinning. The patient is watched for three to four hours, and is then allowed to go back to his barracks. He is assigned to light duty, and is rechecked daily for three or four days.

Fractures through the base of the metacarpals are treated by the

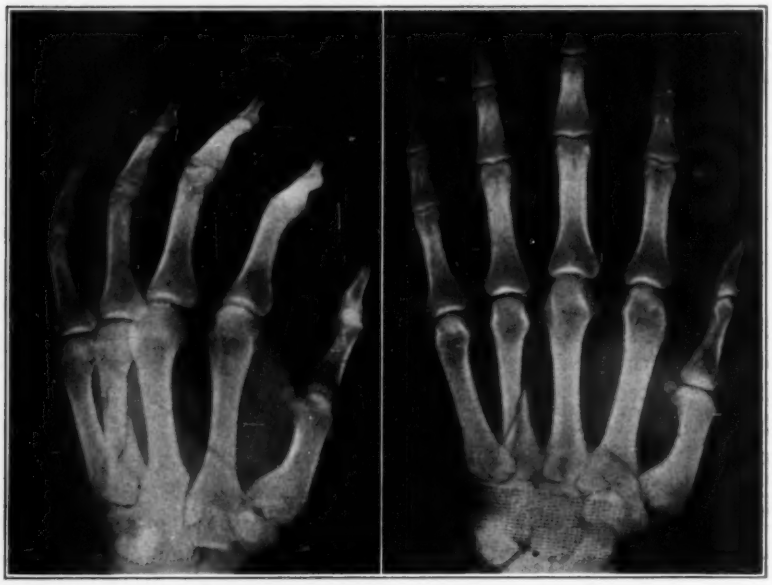

FIG. 3-A

FIG. 3-B

FIG. 3-C

FIG. 3-D

Figs. 3-A, 3-B, 3-C and 3-D: Oblique fracture through the fourth metacarpal before and after pinning.

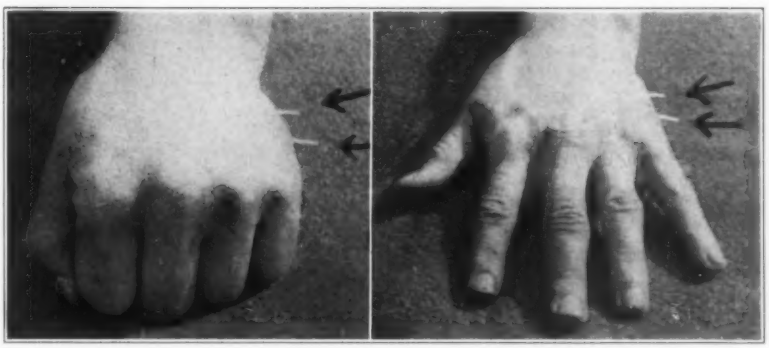

FIG. 3-E FIG. 3-F

Show flexion and extension one hour after operation.

same procedure with a few exceptions. Reduction is obtained by traction and anatomical alignment of the metacarpal heads, with the other hand used for comparison. All pins should be inserted while the hand is clinched and a fist is made, because this method compresses the soft tissues and gives a stable, unyielding metacarpal to drill. Figures 2-A and 2-B show a transverse fracture of the base of the fourth metacarpal, with shortening and displacement, and posterior angulation of the distal fragment.

Figures 2-C and 2-D show the result following pinning. Figure 2-E shows the fracture three weeks later, with callus formation and obliteration of the fracture line.

In oblique fractures through the mid-shafts, double pins may be used conveniently. Figures 3-A, 3-B, 3-C, and 3-D show an oblique fracture through the fourth metacarpal before and after pinning.

Figures 3-E and 3-F show flexion and extension one hour after operation. This patient played basketball three days later.

In removal of these pins, a sterile pair of pliers is used; usually no discomfort is felt, and no sedative is needed. Pins in this series of cases were removed in from four to six weeks, depending upon the amount of callus seen in check roentgenograms.

CONCLUSIONS

The advantages of the treatment described are:

1. Heavy casts or splints are not needed in fractures of the metacarpals.
2. Free use of the hand is established immediately following fixation.
3. Internal fixation maintains proper reduction without slipping of the fragments.
4. Patients feel grateful for the full use of their hands.

THE PLANTARIS MUSCLE

An Anatomical Study of 750 Specimens *

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The small plantaris muscle, with its long slender tendon, is of interest both from the anatomical and phylogenetic viewpoints; additionally, it is of some surgical usefulness.

Cruveilhier regarded the muscle as a vestige in man, believing that, with the assumption of an erect posture, the tendon lost its original insertion into the plantar aponeurosis, and gained a secondary, calcaneal, attachment. The plantaris could thus be regarded as comparable to the palmaris longus in the forearm, and as part of a superficial flexor of the toes. During the progress of postural change, the human foot has become man's sole organ of support (Le Double). When the plantar surface came to rest upon the ground at an angle of 90 degrees with the leg, the plantar aponeurosis acquired fixation to the calcaneum; while thus contributing to the maintenance of the arch of the foot, its muscular portion became regressive. It was Henle's contention that, through special development of the calcaneal protuberance, the tendon of the plantaris was pulled away from the aponeurosis and forced to seek a new fastening point; the secondary point of calcaneal anchorage, being determined by morphological chance, was consequently variable.

In many of the lower animals, the primitive insertion of the plantaris into the plantar aponeurosis has been maintained. Thus, in the American brown bear, the plantaris is as large as the gastrocnemius; originating superior and deep to the gastrocnemius, it becomes a cylindrical tendon in the distal third of the leg; on the internal surface of the calcaneum the tendon then joins the plantar aponeurosis. In apes and in many of the prosimians, the plantaris similarly passes beneath the calcaneum to blend with the plantar aponeurosis. In ruminants generally, and in horses, the muscle originates from the external surface of the femorotibial joint, lies external to the triceps surae and deep flexors of the leg, and terminates weakly by blending with the calcaneal tendon. This insertion is similar to that commonly encountered in man.

The standard textbooks of anatomy describe the human plantaris muscle as a small, spindle-shaped muscle, which originates from the femur just above the lateral condyle and from the adjacent posterior ligament of the articular capsule, in close association with the lateral head of the gastrocnemius. Its proximal part is said to vary from a thin fibrous structure to a muscle belly, equal in size to the lateral head of the gastroc-

* Contribution No. 393 from the Anatomical Laboratory.

nemius. The length of the flesh part is usually between three and four inches. Ordinarily it terminates in a flat, slender tendon which inclines medially in descending between the gastrocnemius and the soleus, on its way to the inner border of the calcaneal tendon. Extending along the medial edge of the latter tendon, it is said to terminate most frequently on the dorsal surface of the calcaneum and in the neighboring fibrous tissues.

Variations in origin are common, the following being described in the anatomical literature (Le Double, von Bardeleben, Henle): the inferior extremity of the external limb of the linea aspera; the posterior ligament of the knee at the intercondylar space; the fascial covering of the popliteus; the fibula, between the flexor hallucis longus and the peroneus longus; the oblique line of the tibia, under cover of the soleus; the fascia of the leg; the lateral condyle of the femur above the origin of the lateral head of the gastrocnemius; and, when bicipital, any two of the above-mentioned areas. The insertion of the plantaris tendon is likewise subject to considerable variation, attachment to neighboring structures taking place at almost any point in the tendon's course. The following areas or points of insertion have been described: the soft tissues between the muscle bellies of the gastrocnemius and the soleus; the inner border of the calcaneal tendon; the dorsomedial surface of the calcaneal tendon at the latter's insertion; the bursa between the calcaneal tendon and the calcaneum; the small tuberosity on the superior surface of the calcaneum, located anteromedially to the insertion of the calcaneal tendon; the internal portion of the laciniate ligament; the superior surface of the calcaneum and the fibrous and fatty tissues situated immediately in front of the calcaneal tendon; and the plantar aponeurosis.

The plantaris muscle, like the psoas minor and palmaris longus, is sometimes absent. In 1400 legs studied by Gruber, there were 105 in which there was a complete absence of the plantaris muscle and tendon, an incidence of 7.5 per cent. Schwalbe and Pfitzner recorded thirty-two cases of agenesis in 520 legs studied, an incidence of 6.2 per cent.

The present authors have not encountered a single instance of greatly abbreviated tendon, or a case in which the muscle origin was unusual. This means that major variations are uncommon. Such variations as do occur affect the insertion, not the origin.

In the present study, the authors are concerned with variation in the form of the tendon, and with the absence of the entire muscle.

MATERIALS AND METHODS

This report is based upon a study of 750 lower extremities of American whites and negroes, consecutively examined. In the last 150 extremities, records were obtained on the form and position of the tendinous insertion. For each major type, a specimen was selected to illustrate the distal part of the tendon (Fig. 1-*1* to *5*), and the area of calcaneal attachment (Fig. 1- *6*).

OBSERVATIONS AND DISCUSSION

In most instances the tendon of the plantaris terminates in a fan-shaped, aponeurotic expansion in relation to the medial border of the distal extremity of the calcaneal tendon. The plantaris tendon may be implanted in front of the calcaneal tendon, the long axis of the insertion lying parallel, at a right angle, or oblique to that of the calcaneal tendon; it may touch the medial margin of the calcaneal tendon, then stretch away obliquely toward the opposite side of the foot; it may extend posteriorly to overlap the calcaneal tendon on the latter's external aspect; or it may have its insertion into the calcaneal tendon, sending no slip, or negligibly fine ones, to the os calcis. On the basis of these definite anatomical differences, four tendon types have been established:

Type 1. This type, representing the commonest mode of insertion of the plantaris tendon, occurs in seventy-one of 150 cases (48 per cent.). The plantaris tendon inserts by a short fan-shaped expansion into the medial extremity of the superior tuberosity for insertion of the calcaneal tendon (Fig. 1-*1*). In some instances the tendon also sends thin slips to the adjacent medial border of the calcaneal tendon. These slips resemble fascial strands, not true aponeurotic extensions; they are readily removed from the larger tendon.

Type 2. In this type, second in the order of frequency, the plantaris tendon inserts into the calcaneum, 0.5 to 2.5 centimeters anterior to the calcaneal tendon (Fig. 1-*2*); the long axis of the tendon is usually at an angle with, not parallel to, the long axis of the foot itself. This type occurs in forty-eight of 150 specimens (32 per cent.). The insertion supports the anterior wall of the bursa of the calcaneal tendon (Fig. 1-*2* at cross). When large, the tendon frequently radiates in fan-shaped manner to the laciniate ligament and the fascia overlying the medial aspect of the calcaneum (Fig. 1-*5*). Tendinous insertions of *Type 2* are frequently quite expansive (Fig. 1-*5*), and often involve the fascial and ligamentous structures on the superior and medial surfaces of the foot.

Type 3. In the cases belonging in this category, the tendon of the plantaris is usually broad at the insertion; but, whether of large or medium size, it invests the dorsal and medial surfaces of the terminal portion of the adjacent calcaneal tendon (Fig. 1-*3*). The area of attachment is sometimes lower than that of the tendon of *Type 1* or *Type 2*. This type occurs in twenty-three of the 150 specimens (15 per cent.).

Type 4. Here the plantaris tendon inserts chiefly into the medial border of the calcaneal tendon from one to sixteen centimeters above the insertion of the latter into the calcaneum. Occasionally, as in Figure 1-*4*, a lowermost slip may reach the bone. It is the least common of the types considered worthy of classification; only seven examples occur in the 150 cases (5 per cent.).

In the present series of 750 extremities, the muscle is wanting in fifty cases, an incidence of 6.67 per cent. In sets tabulated from the literature, the percentage absence is 7.05 (187 in 2650).

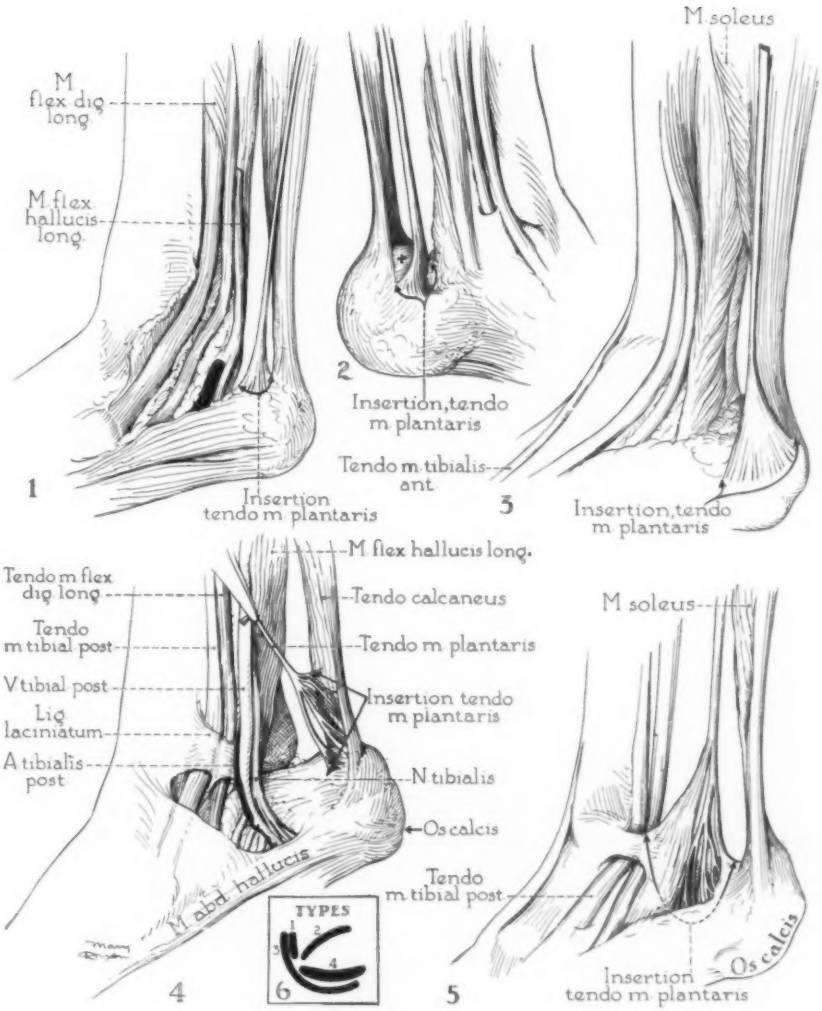

FIG. 1

Types of tendinous insertion of plantaris muscle, medial aspect of leg; *2* is of the left extremity; *1*, *3*, *4*, and *5* of the right. Bursa in *2* is indicated by cross.

Selected examples: *6* indicates areas of calcaneal insertion of plantaris tendon (Types *1*, *2*, and *3*) and of combined calcaneal and plantaris tendon (Type *4*), with areas of insertion numbered to record types.

In *6* the tendon for Type *3* represented is an unusually long one. For the tendon of Type *2*, one of intermediate position is diagrammed; others would lie in front of or behind the area indicated, as if moving on the medial extremity as an axis.

It is clear, then, that the plantaris tendon, in a preponderant percentage of cases, gains a virtually separate insertion into the os calcis. This it may do in any one of three principal ways: by implantation into the os calcis just in front of the calcaneal tendon, the long axis of the line of fixation being parasagittal; by insertion into the bone in such a way that the long axis is almost transverse, beginning, as in the former instance, at

the medial margin of the calcaneal tendon; by attachment to the calcaneum medially, or to the calcaneal tendon posteromedially (Fig. 1-*6*). In the first and second instances, the posterior border of the plantaris tendon is in contact distally with the anterior border of the calcaneal tendon; in the third instance, the lateral, or anterolateral surface is contiguous with the posteromedial surface of the calcaneal tendon.

Even in those cases in which the insertion is into the calcaneal tendon, a few fibers may be sent downward for independent attachment to the os calcis.

The present study is not concerned with the differences in the incidence of agenesis in males and females. However, this phase has been dealt with by Gruber, and by Schwalbe and Pfitzner, with the following results (Table I):

TABLE I

Reported by	Males		Females	
	No. of Legs	Agenesis	No. of Legs	Agenesis
Gruber	700	64	700	41
Schwalbe and Pfitzner	344	22	176	10
Totals	1044	86 (8.2 per cent.)	876	51 (5.8 per cent.)

In the fifty cases of absence of the plantaris in the present authors' series, there are thirteen subjects in which agenesis is bilateral, and twenty-four specimens in which it is unilateral. Thus, in approximately one-third of those persons in whom the muscle is wanting, it is bilaterally absent. The muscle is absent on the right side in nineteen and on the left side in thirty-one of the forty-nine cases. Of the twenty-four specimens with unilateral absence, eighteen are left, while only six are right. When the muscle and tendon are poorly developed on one side, they are usually equally weak on the opposite side.

Surgical utilization of the plantaris tendon has been discussed by Pilcher and Glissan. Pilcher, in particular, has pointed out the advantages possessed by the tendon in the repair of herniae, as compared with grafts of fascia lata. He recognizes that the muscle is absent in approximately 7 per cent. of the cases, and that the tendon may be of inadequate size and strength in an additional 9 per cent. of the cases. Pilcher further points out that the tendon is often palpable; although its absence cannot be determined infallibly in this manner, yet it is a simple matter, by this procedure, to determine whether it is adequate for hernial repair. Confusion may result in those rare cases in which the soleus possesses an accessory tendon situated medially to the calcaneal tendon. But such an accessory would be more taut and thicker, since it is more fleshy than the

tendon of the plantaris (Pilcher). Only one example of such an accessory soleus tendon was encountered in the last 200 legs studied by the authors. Glissan has utilized the plantaris tendon as a living suture for repair of gaps in the flexor tendons of the palm, in tendon transplants about the ankle, in repair of a ruptured coracoclavicular ligament, and in the repair of a slipping patella by Gallie's technique. He states that the tendon possesses advantages over fascia lata in being easier to handle surgically, in being calculable as to length, and in having the property of lateral stretching,—a feature which renders it ideal for hernial repair.

SUMMARY AND CONCLUSIONS

The plantaris muscle and tendon may be regarded as the vestigial remains of a primitive flexor muscle of the toes, which, originally continuous with the plantar aponeurosis, later was rendered discontinuous through intermediate attachment to the calcaneum.

The plantaris muscle and its tendon are subject to considerable variation in both the points of origin and of insertion. In an examination of 150 lower extremities, the authors have encountered four types of insertion of the tendon.

In 750 consecutive lower extremities examined by the present authors, the plantaris muscle was absent in fifty (6.67 per cent.). In one-third of the specimens in which the muscle was missing, the absence was bilateral.

The surgical utilization of the plantaris tendon is particularly indicated as a desirable substitute for the fascia lata in hernial repair, tendon transplants, and repair of ligaments.

NOTE: The authors gratefully acknowledge the generosity of Prof. O. F. Kampmeier, Prof. T. T. Job, and Dean J. J. Sheinen who made available material in their laboratories at the Medical School of the University of Illinois, Loyola Medical School, and the Chicago Medical School, respectively.

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INJURIES OF THE PELVIS

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The purpose of this paper is to emphasize a method of treating certain types of injuries of the pelvis, first described by Watson-Jones in 1938, which has not received much space in American medical literature. It is a simple and highly effective way of treating such injuries.

The pelvic ring is formed by the articulation of the two innominate bones with each other anteriorly at the pubic symphysis, and with the sacrum posteriorly. A fracture in only one portion of this ring does not result in gross displacement, because of the stability of the remaining portion of the ring, but in the event of a second injury to another portion of the ring there may be gross displacement.

Injuries caused by lateral compression of the pelvic ring arise when pressure is applied on opposite sides of the pelvis, as in the case of the individual thrown against his companion in the seat of an automobile, or when the victim is crushed sideways between a vehicle and an immovable object such as a wall. This type of injury causes a bilateral fracture of the pubic rami, or a unilateral fracture of both rami with a separation of the pubic symphysis; in other words, the injury is to the anterior portion of the pelvic ring only. The displacement is usually minimal, because of the muscle attachments, and, regardless of displacement, there is no shortening of either limb, and no alteration in the alignment of weight-bearing joints. Complications are rare, and treatment in such cases consists merely in keeping the individual in bed until healing is complete, a period of about six weeks.

The injuries of the pelvis, which result in a complete disruption of the pelvic ring, are caused by an anteroposterior compression of the pelvic ring, occurring when a person is caught between a vehicle and a wall while facing either one, or in a head-on collision at high speed. A knowledge of the mechanism of the injury is the key to its successful treatment. These are injuries of both the anterior and posterior portions of the pelvic ring, and comprise a high percentage of pelvic injuries. The commonest, perhaps, is a dislocation of the pubic symphysis with a dislocation of the sacro-iliac joint, as in Case 1. Less commonly, there is a fracture of both pubic rami on one side, with a dislocation of the sacro-iliac joint, or a dislocation of the symphysis pubis with a fracture of the ilium, as in Case 2. Usually the fracture is closer to the sacro-iliac joint than it is in the second case.

Many methods of treating this type of injury have been proposed, among which are well-leg traction, Russell traction, traction of both legs,

skeletal traction, pelvic slings and girdles, and several operative procedures including wiring of the fragments, and even more drastic procedures. Watson-Jones states that in all of these procedures the patient has been treated lying on his back, when in reality the key to the treatment of this type of injury is an appreciation of the direction of the force causing the injury,—that is, an anteroposterior force. He compares this type of injury to a partially opened bivalved shell, and suggests merely treating the patient lying on his side rather than on his back.

His method is simple and highly effective even in those cases complicated by bladder or urethral rupture. The author has treated cases in the past with adhesive leg traction and pelvic sling, but believes the method described by Watson-Jones offers many advantages from both the military and civilian standpoints. The patients are comfortable, and can be evacuated either from a zone of combat or from a hospital to their homes in a very short time. The procedure is the very essence of simplicity and results in good reduction with a good prognosis.

Watson-Jones' technique of postural reduction by lateral recumbency is as follows: Slight separation of the symphysis pubis with subluxation of the sacro-iliac joint may be reduced without anaesthesia. If there is a gross displacement, a spinal or general anaesthetic should be given. A plaster table or any form of pelvic rest is used, with the peroneal post removed. The patient is placed on his uninjured side with the ilium and greater trochanter lying on the pelvic rest; the two lower extremities are supported by an assistant. In many cases the reduction is accomplished by the time the patient is in this position. If the pubic bones are not approximated perfectly, and the posterior superior spine of the ilium is still unduly prominent, pressure is applied over the crest of the dislocated ilium, pushing it down and rotating it toward the normal half of the pelvis. Accuracy of reduction should be checked by x-ray at this point, and, if necessary, the patient should be placed on the injured side, thus adding the body weight to the compression. The iliac crests are protected by means of adhesive felt, and a double hip spica, extending from the lower ribs to just above the knees, is applied. The pelvic rest is then cut out, and the defect padded with felt and closed with plaster. An x-ray is taken through the cast to check the reduction. The patient is encouraged to move about and roll from side to side. Quadriceps exercises are instituted, and immobilization is continued for at least three months; the cast is changed if necessary at the end of the first six weeks in order to keep it well molded across the iliac crests.

Two cases are reported. The simplicity of procedure and management, the comfort of the patient, and the excellence of the result have been very gratifying.

CASE 1. W. G., a white male, aged twenty-four, was brought to the Hospital on a litter about 11:00 A.M., September 29, 1942. When first seen he was lying relatively quiet, complaining of pain in the pubic symphysis and in the left sacro-iliac joint. He stated that he had been working on the tail wheel of a four-motored bomber which had

FIG. 1-A

On admission September 29, 1942.

FIG. 1-B

Fourteen weeks after reduction.

been inadvertently lowered. The tail of the bomber had rested on the lower portion of his back while he was on his knees, bent forward.

Examination on admittance was negative except that the patient had marked tenderness over the pubic symphysis and left sacro-iliac joint. He was able to move both

lower extremities fairly well, but had considerable pain in the pelvis when attempting to do so. Urine passage and laboratory examination were normal. Roentgenograms taken September 29, 1942, showed a widening of the pubic symphysis of 1.5 centimeters and a separation of the left sacro-iliac of 0.3 of a centimeter (Fig. 1-A).

At 1:00 P.M., the dislocation of the pelvis was reduced after the manner described by Watson-Jones, with the patient lying on his left side on a Hawley table, and a plaster-of-Paris double hip spica was applied from the level of the sixth rib to just above the knees. No anaesthetic was required, and only .016 of a gram of morphine sulphate and .00043 of a gram of scopolamine hydrochloride were given as preoperative medication. The patient was quite comfortable, requiring only .09 of a gram of nembutal at 2:00 A.M., September 30, 1942, and no medication thereafter during his entire hospital stay. Postoperative roentgenograms showed good but not quite perfect reduction. However the pubic symphysis has been narrowed and the sacro-iliac joint has been reduced.

Quadriceps exercises were started on October 2, 1942, and kept up for five minutes out of each waking hour during the patient's stay in the Hospital. Routine care included turning the patient on his abdomen twice each day.

After six weeks, the cast was still well molded around the ilium, and the tonus of all leg muscles was good. On December 29, 1942, the cast was removed, and there was no sign of tenderness over either the pubic symphysis or the left sacro-iliac joint. Roentgenograms taken January 7, 1943, showed complete reduction of the left sacro-iliac joint and the pubic symphysis (Fig. 1-B). On January 2, 1943, the patient was allowed to walk a few steps. Aside from a slight swelling and a few mild cramps of the left leg there was no discomfort. Daily exercise and walking were increased, and the patient was discharged from the Hospital January 31, 1943, on a four weeks' furlough. He was re-examined March 1, 1943, and returned to full military duty March 10, 1943.

Case 2. K. W., a white male, aged twenty, was brought to the Hospital at 6:55 P.M., August 12, 1942, after injury in an airplane accident about 5:00 P.M. He had been wedged between the top turret and the floor of the plane, so as to receive antero-posterior compression. At the first examination he was conscious, lying on a litter, obviously in great pain in spite of the administration of .03 of a gram of morphine sulphate immediately following the accident. He was in moderate shock, with multiple abrasions of the back, arms, and legs, and an eight-centimeter laceration over the right knee. The right lower extremity was held in the typical position of a posterior dislocation of the hip; there was three inches of shortening, and the pelvis was asymmetrical. The shape of the right ankle was distorted with lateral and posterior displacement of the foot. Sensation of the foot and toes was impaired, indicating an injury of the right sciatic nerve, and the patient was unable voluntarily to flex or extend the toes. Two hundred and fifty cubic centimeters of plasma was given at once, and 150 cubic centimeters of clear urine was obtained by catheter. Roentgenograms taken August 12, 1942 (Fig. 2-A), showed a complete transverse fracture through the right acetabulum and posterior dislocation of the head of the right femur, a separation of the pubic symphysis of two centimeters, and of the right sacro-iliac joint of five-tenths of a centimeter. There were incomplete fractures of the superior and inferior rami of the left pubis. The general condition of the patient improved, and at 9:00 P.M. he was given .016 of a gram of morphine sulphate and .00043 of a gram of scopolamine hydrochloride. He was taken to the operating room where a general anaesthetic was given. Débridement and closure of the knee wound were done, the hip was reduced after the manner of Allis. The patient was then rolled onto his left side, and the pelvic dislocation reduced by lateral recumbency plus slight pressure on the crest of the right ilium. The ankle fracture was reduced, and a double hip spica was applied from the sixth rib to the toes of the right lower extremity and to just above the knee on the left.

Following reduction, 1000 cubic centimeters of 5-per-cent. glucose was given intravenously. A stimulating dose of tetanus toxoid was administered and .016 of a gram of morphine sulphate was required about every six hours for the first three days.

FIG. 2-A

On admission August 12, 1942.

Postoperative roentgenograms of all fractures were taken August 14, 1942, and those of the pelvis showed reduction of the dislocated right femur and reduction of the acetabular fracture. The separation of the pubic symphysis and the right sacro-iliac joint had been corrected. These pictures, taken through a wet cast, failed to photograph well, but the roentgenogram taken September 22, 1942, showed the condition at that time.

Quadriceps exercises, requiring five minutes out of each waking hour, were started on August 18, 1942, and were continued throughout the patient's stay in the Hospital. Routine turning and the general care of any patient in a large cast were carried out.

On September 24, 1942, the foot and leg portion of the cast was removed; the fibular fracture had healed. The patient began to flex the toes of the right foot slightly, but was unable to extend them. The area of anaesthesia extended over the dorsum of the foot and anterolateral surface of the leg about five inches above the ankle joint. A removable posterior molded splint was applied to hold the foot at a right angle, and radiant heat and light massage of the leg muscles were begun. Spot roentgenograms of the head of the femur were taken at four-week intervals. The second and third roentgenograms showed questionable changes in the density of the head; these disappeared in later roentgenograms.

On November 14, 1942, the spica cast was removed. Muscle tonus of both quadriceps was good, and there was a questionable increase in motion of the toes, although the foot could not be held in dorsiflexion. Motion of the right hip was good and without pain. The patient was allowed up in a wheel chair on November 16, 1942, and on crutches November 20, 1942. Knee and hip exercises were increased daily. There was mild circulatory oedema of both lower extremities which persisted for about five weeks after the removal of the cast. Partial weight-bearing on a short walking cast (until a foot-drop splint could be made) was allowed on December 21, 1942. Since there was no pain, and practically full motion of the hip had been attained, complete weight-bearing was allowed December 31, 1942. Roentgenograms taken January 7, 1943, showed maintenance of the reduction of the right sacro-iliac joint and pubic symphysis with complete healing of the acetabular fracture in good position (Fig. 2-B). There is some haziness of the head of the right femur.

On January 2, 1943, the patient began to walk to the mess hall with the aid of

FIG. 2-B

January 7, 1943. Showing complete healing of the acetabular fracture in good position, and reduction of the right sacro-iliac joint and symphysis pubis maintained.

crutches. Walking, with no other aid than a cane, was begun January 21, 1943, and the patient was discharged from the Hospital on February 4, 1943, for a convalescent furlough. Upon his return a spot roentgenogram taken of the right hip, on April 2, 1943, showed a normal appearing hip. Because of the prolonged nature of hospital care and physiotherapy, the patient was transferred to a general hospital on April 20, 1943. At the time of his discharge from this Hospital, the motion in the hip and back was normal, and the motion of the toes was improving. The function of the right sciatic nerve was still incomplete, but the pelvis and hip were well, though naturally a guarded prognosis of the function of the hip and foot have been given.

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FRACTURE OF THE SCAPULA WITH DISPLACEMENT

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Fractures of the scapula are relatively uncommon. In view of this fact, textbooks on fractures devote little space to the consideration of injuries to this bone. The varieties include longitudinal fractures of the body of the bone, avulsion of the spinous process, avulsion of the acromion, and subglenoidal and glenoidal fractures. Due to the anatomical

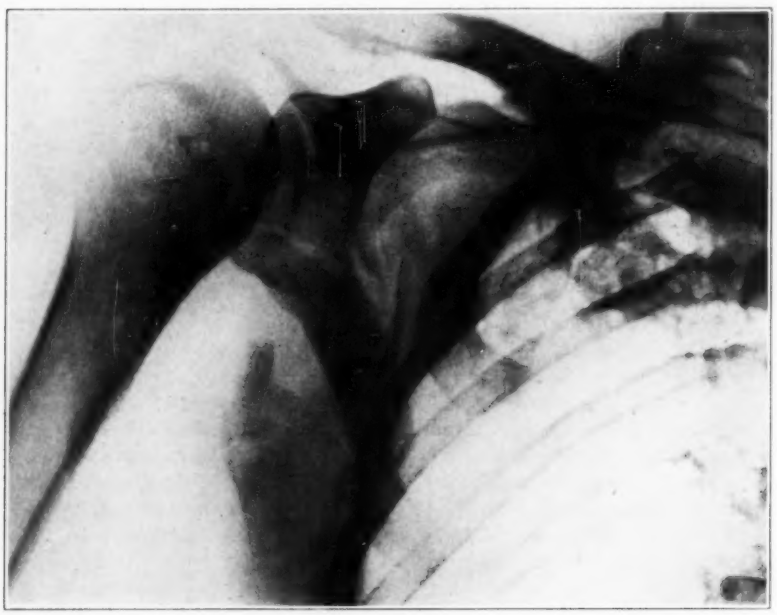

FIG. 1

Roentgenogram of the right shoulder region taken on the day after the injury, showing comminution and displacement of the scapula.

position of this flat bone, very little displacement is ordinarily seen, and measures aimed at alleviating the initial pain of injury suffice in the treatment of most fractures of the scapula. As in fractured ribs, instantaneous and prolonged relief from pain is secured by the infiltration of local anaesthetic substances into the area of the fracture.[3] During the past four years, the authors have treated six patients by this method alone. No form of immobilization is needed, if there is no or minimal initial displacement of the fragments. The degree of displacement in subglenoidal

fractures of the scapula is never great, but these fractures, as well as those in which the fracture line transects the interarticular face of the glenoid (glenoidal fractures), frequently result in subsequent limitation of motion at the shoulder, possibly because of the initial damage to the joint capsule and subsequent stiffening, due to adhesion of the layers of the capsule following trauma and hemorrhage. Two of the three fractures involving the subglenoid area treated during the past four years have required subsequent manipulation of the shoulder to increase the patient's range of motion following osseous union.

The primary object of this paper, however, is to discuss the types of scapular fractures which require open reduction, and to record our experience with one patient who was treated by excision of the free inferolateral fragments. Reference to the literature reveals only one similar case. [4] Reggio and Fischer each reported one open reduction of a glenoidal fracture. As a general principle, fractures of this bone, with gross displacement which, if not reduced, might subsequently interfere with function, should be treated by open reduction and fixation adequate to maintain the reduction.

The prompt recovery of the authors' patient, including quick return to former duties, would indicate that fractures similar to the one described should be routinely treated by excision of the free fragments. The decision to use this method is a logical conclusion drawn from the minimal disability presented in cases of pulmonary tuberculosis, where resection of the scapula is performed as an adjuvant procedure in connection with thoracoplasty, and where resection of this bone has been performed for relief of pain and disability following thoracoplasty [1].

CASE REPORT

The patient, R. S., aged fifty-three, employed as a switchman by a railway company, was found along the railroad tracks. He had been struck in the posterior aspect of the right shoulder by a train moving at a moderate rate of speed. He was not discovered until a short time after the train had passed; he never lost consciousness. When brought to the Hospital, the only evidences of injury were in the neighborhood of the right upper and posterior trunk, and in the right shoulder. The first roentgenogram taken showed a comminuted fracture of the right scapula with marked displacement of the fragments (Fig. 1). There were at least three major fragments, one involving the inferolateral portion of the right scapula being rotated upon itself and displaced further laterally. There were also several smaller fragments which had resulted from the comminution. The roentgenogram also demonstrated fractures of the third and fourth ribs on the right side. Upon examination a few hours later, it was discovered that the patient's disability consisted largely of pain upon attempts at abduction of the arm, which motion could not be executed satisfactorily, due as much to weakness of this function as to pain. An attempt to replace the fragments by external manipulation was not successful. Three days after admission, excision of the inferior half of the infraspinous portion of the right scapula was carried out under local infiltration anaesthesia of .5-per-cent. solution of procaine hydrochloride. After infiltration of the operative field, a seven-inch incision was made vertically along the posterior axillary line. The four fragments, which together made up the inferior one-half of the infraspinous portion of the bone, were excised by stripping them subperiosteally from the attached muscles. The muscles were sutured together in as nearly an anatomical relation as possible. The subcutaneous tissues were

closed with interrupted sutures of cotton, and the skin margins were approximated with a running suture of cotton.

The patient's postoperative course was ideal, except for a slight amount of pain which was easily controlled by sedatives. He was discharged from the Hospital on the fourth day after operation. On this date he could already carry out about one-third of the normal range of motion of the right shoulder. This motion rapidly increased, as pain diminished. The range of active motion which the patient could execute on the ninth postoperative day was extensive (Figs. 3-A, 3-B, and 3-C). At this time the patient had no pain, and his only disability was lack of the final one-third of both active abduction and external rotation. After this date, active motion further increased, and he was allowed to return to work three and one-half weeks following the operation. At that time he lacked only one-fourth of the extremes of abduction and external rotation. That degree of limitation of motion persisted for the ensuing four weeks, during which period a gradual improvement occurred. Seven weeks after operation, the motion at the right shoulder was normal. This state has persisted until the present date (ten months following operation).

DISCUSSION

Open operation was indicated in the case presented, because of the wide separation and comminution of fragments. The findings at operation confirmed the suspicion that muscle was interposed between the osseous fragments. The length of this patient's disability was only one-third of the average time of disability, as observed by the authors in the treatment by conservative means of patients with non-displaced fragments of the body of the scapula. The short period of hospitalization and the early return of function are important factors.

FIG. 2

Roentgenogram taken immediately after operation, showing appearance of scapula after excision of the free inferolateral fragments. Note that, although there is a fracture line through the glenoid, its face is not comminuted or displaced.

The procedure in this case and the observations made are not to be construed as favoring treatment of all scapular fractures by radical means. In the non-displaced fractures a satisfactory recovery, including a return of function of the shoul-

FIG. 3-A FIG. 3-B FIG. 3-C

Range of motion on the ninth day, following excision of free fragments in fracture of the scapula.

der after a somewhat more protracted period, usually occurs. However, the course and outcome in this case suggest that in fractures of this bone in which there is separation of the glenoid fragments, as reported by Fischer and Reggio, open operation with fixation should be carried out, and where gross separation of the fragments exists, as in this case, excision of the fragments should be done. This treatment is in line with the recommendation of other authors who have shown that excision of patellar [6] and olecranon [7] fragments has resulted in a shortened period of disability from these injuries.

FIG. 4

Roentgenogram taken ten months after the injury. Although there has been no immobilization, the remaining scapular fragments have united.

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THE USE AND ABUSE OF THE ANATOMIC SPLINT IN THE TREATMENT OF FRACTURES OF THE LOWER EXTREMITY*

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Surgeons have been slow to accept the anatomic splint devised by Roger Anderson for the treatment of fractures of the long bones. This has been due to a number of factors:

1. Good results with methods already in use;
2. Familiarity with methods already in use, and disinclination to adopt new methods with which they are unfamiliar;
3. Fear of infection following the pins from the surface to the bone;
4. The method appears, on initial examination, to be complicated;
5. The anatomic splint is an expensive piece of apparatus;
6. The widespread use of the open reduction, which has followed the development of the aseptic technique, and the discovery of several non-irritating metallic substances.

Gradually, however, the advantages of this method have forced their way into the consciousness of the profession, and, as experience with the splint has accumulated, its adherents have become more numerous. Despite the continually expanding use of this method of treating fractures, little has appeared in the literature regarding it, until very recently, save the writings of its originator.

The extensive experience with this splint at Walter Reed Hospital by Sloat and Peterson has brought it to the attention of the Armed Forces. The recent publications of Bradford and Wilson delineating their experiences with the anatomic and Haynes splints at the American Hospital in Britain, have received considerable favorable attention. Bradford states that there are four methods of treating fractures:

1. Closed reduction;
2. Open reduction;
3. Traction;
4. Fixing the fragments with pins or screws, and utilizing the fixation units to accomplish reduction and immobilization.

He points out that the disadvantages of the last method are possible contamination of the pins, either at the time of introduction, or by infection along the sinus tract which may form about the pin, and the necessity for the surgeon to learn to use the apparatus properly. He also lists the following advantages of this method:

1. It presents a more perfect and accurate means of obtaining reduction.

* Received for publication October 23, 1942.

2. It provides firm fixation.
3. It avoids distraction when properly used.
4. It permits early ambulation.

Both the above authors say that the pin-fixation method has proved particularly valuable in cases of infected compound fractures, when dressings and skin-grafting may be done without disturbing the alignment; and in spiral fractures where plaster alone is incapable of maintaining reduction. In the sixty-one cases in which they studied this method of treatment, there was but one instance of a superficial skin infection without bone involvement.

The discourses dealing with this type of fixation, which have appeared up to the present time, are universally favorable, though cautious, reports. In them one may read of certain precautions which must be observed in using these splints. None, however, site specific instances in which errors have been made in the use of the apparatus.

The author was first induced to use the anatomic splint while in private practice, because it appeared to offer a means whereby hospital time could be markedly reduced, and stiff knees avoided. At his present station he has had the opportunity to become more proficient in its uses, and, in learning to use it, has made a number of mistakes. He has had no personal experience with the Haynes apparatus, the Haboush method, or the Stader reduction splint [8, 9].

The purpose of this communication is to point out the errors that have been committed in learning to use this splint, and to emphasize and amplify the advantages and disadvantages which to the author it seems to possess. Nine case reports are, therefore, presented, each of which illustrates an imperfection in technique, a disadvantage of this type of treatment, or an instance in which the anatomic splint presents an advantage not obtainable by one of the more commonly used methods of treatment.

CASE REPORTS

CASE 1. D. H. S., a Private in the United States Marine Corps, aged twenty-one years, was admitted April 16, 1941, with a simple fracture of the right tibia and fibula. In another city, eleven days before admission, the patient had been struck by an automobile, sustaining an oblique fracture of the mid-tibia, and of the fibula a little lower down. Some pulmonary damage had also occurred and this engaged the primary attention of his physicians. A plaster encasement was applied to the leg without reduction. His chest condition cleared up nicely, and he was transferred to this Hospital.

Roentgenograms, taken on admission, show the oblique fracture of both bones with some overriding and lateral displacement of the lower fragment (Fig. 1-A).

Under spinal anaesthesia the half-pin units were applied above and below, and the fracture was reduced in the anatomic splint. The pins in this instance were introduced, not transversely, but halfway between the horizontal and perpendicular planes. This was done purposely in an effort to obtain roentgenographic views in both planes unobstructed by the bars of the half-pin units. The result of this placement was that the second cortex was penetrated by only the lower of the two upper half-pins, and the upper of the two lower half-pins. A roentgenogram taken on April 18, 1941, after the reduction, shows this failure of penetration of the second cortex, and reduction with some

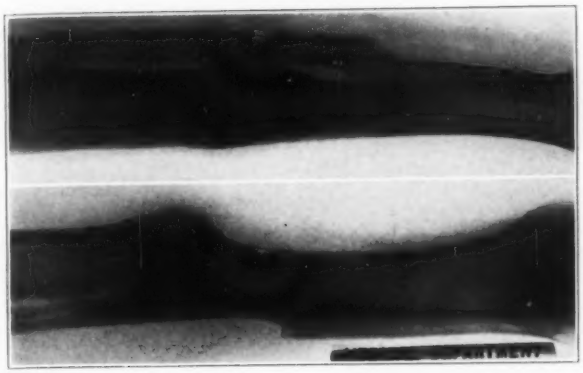

FIG. 1-C

Fig. 1-A: Case 1. D. H. S. April 16, 1941. Showing oblique fractures of both bones, with overriding and lateral displacement of the distal fragment.

Fig. 1-B: April 18, 1941. Postreduction roentgenogram showing anterior angulation and failure of the pins to penetrate the second cortex.

Fig. 1-C: December 29, 1941. Showing abundant callus with fracture line still visible on the lateral side of the tibia.

FIG. 1-B

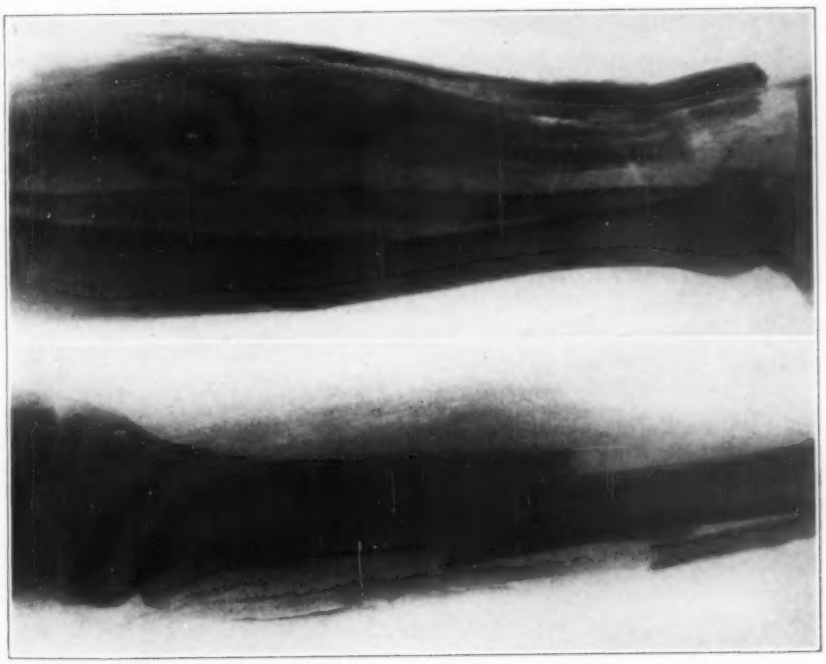

FIG. 1-A

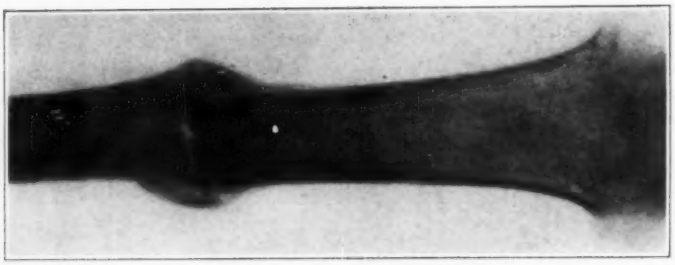

FIG. 2-D

Fig. 2-C: February 20, 1941. Showing reduction and correction of distraction.

Fig. 2-D: July 3, 1941. Roentgenogram taken six months after injury shows the fracture to be well healed.

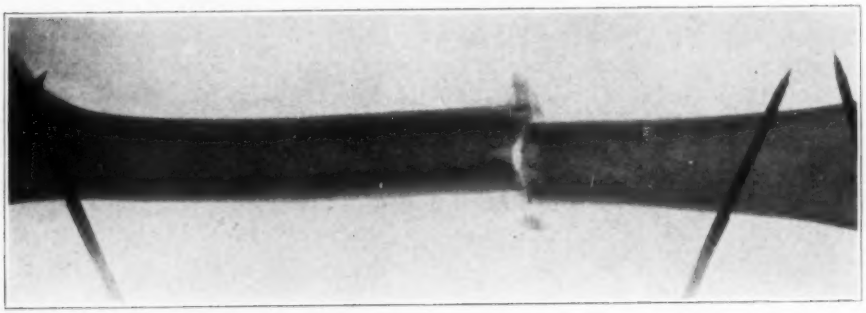

FIG. 2-C

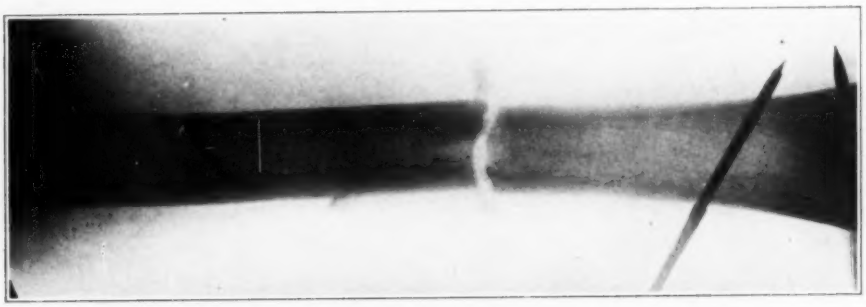

FIG. 2-B

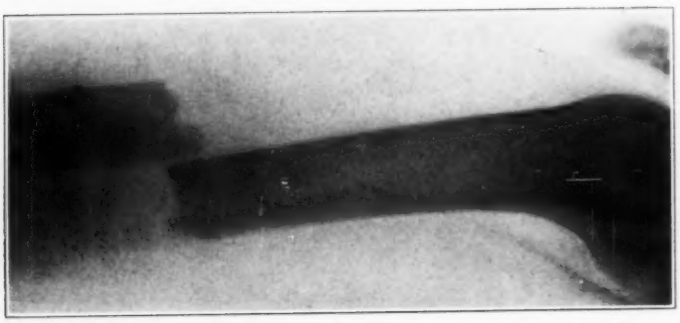

FIG. 2-A

Fig. 2-A: Case 2. S. A. W. January 19, 1941. Roentgenogram taken on admission shows fracture of the mid-shaft of the right femur.

Fig. 2-B: January 23, 1941. Postreduction roentgenogram shows distraction.

anterior bowing (Fig. 1-B). The absence of anatomic reduction, later slipping, and delayed union are strictly attributable to this misapplication of the pins.

On June 17, 1941, the pins and plaster were removed. There was no clinical union, and a small pressure ulcer had developed over the apex of the anterior bowing. A long leg plaster was applied, and on July 16, 1941, weight-bearing was allowed. On July 22, 1941, motion at the fracture site persisted and a walking boot was applied. Roentgenograms on this date showed maintenance of good position with good callus formation, chiefly toward the medial side. The patient pounded around on the leg until September 29, 1941, at which time there was firm clinical union, and good callus was shown in the roentgenogram. He then returned to duty.

On December 28, 1941, he was readmitted for an unrelated condition. At this time a large lump of callus was observed at the fracture site. Roentgenograms the next day (Fig. 1-C) showed much callus and good position.

This case is one of incomplete reduction and delayed union of the tibia due to faulty technique.

CASE 2. S. A. W., a Corporal in the United States Marine Corps, aged twenty-three years, was admitted January 18, 1941, suffering from a simple fracture of the right femur, comminuted fractures of both patellae, multiple fractures of the tarsal and metatarsal bones of both feet, and shock. The patient had fallen from a second-story window two hours before admission (apparently landing on his toes and falling to his knees, instead of landing on his heels). His general condition was such that, after the institution of shock therapy, the right lower extremity was placed in Russell traction, the left in a Thomas splint, and molded plaster boots were applied.

Roentgenograms of the right lower extremity taken on January 19, 1941, showed:

1. Transverse fracture of the femur near its mid-portion with posterior displacement of the lower fragment and several centimeters of overriding (Fig. 2-A);

2. Multiple fractures of the patella producing about five fragments, with very little separation of the fragments;

3. Irregular comminution of the distal aspect of the external and middle cuneiforms and of the proximal end of the second metatarsal, and an increased separation of the first and second metatarsals due to slight lateral subluxation of the second and third metatarsals.

Views of the lower left extremity revealed:

1. Multiple fractures of the patella producing about five major fragments which show considerable separation;

2. Fracture through the navicular about one and two-tenths to two centimeters from its inner margin, with slight separation;

3. Diagonal fracture across the lower outer corner of the cuboid, with detachment of a triangular fragment of bone about one and five-tenths centimeters in size, and very little deformity.

Bedside films of the pelvis and of the thoracic spine were essentially negative.

On January 22, 1941, excision of left patella under spinal anaesthesia was done, and on January 23, 1941, under sodium pentathol the Roger Anderson half-pins were introduced into the right femur, and reduction in the anatomic splint was accomplished. Fixation was secured by a single bar between the half-pin units. Postreduction roentgenograms illustrate overextension (Fig. 2-B).

On February 3, 1941, he was again placed in the anatomic splint, and the fracture was impacted.

On February 15, 1941, he was replaced in the anatomic splint, and the anterior angulation of the femur was corrected (Fig. 2-C). A cystitis then developed, and on March 4, 1941, some discharge about the upper pins was noted.

On March 24, 1941, motion of the left knee was 160 to 175 degrees, and of the right knee, 170 to 180 degrees.

Psychic vomiting then occurred, and the patient became depressed and refused to cooperate. This, and pain about the upper pins in moving the thigh all militated against normal progress. On April 19, 1941, an acute tonsillitis developed. The pain about the pins became so intense that on April 21, 1941, a spica was applied to just above the knee.

On May 1, 1941, a left otitis media, with rupture of the drum, developed, which drained for several days. From this time on his convalescence was one of gradual improvement. The plaster was removed, and walking with crutches without weight-bearing was allowed.

Roentgenograms taken July 3, 1941, show excellent healing, with some anterior bowing (Fig. 2-D).

Examination on November 10, 1941, disclosed the legs to be of equal length, and no pelvic tilt. Motion in the hip, knee, and ankle joints was as follows:

Hip	Right	Left
Internal rotation	normal	one-half normal
External rotation	30 degrees	normal
Abduction	normal	normal
Adduction	normal	normal
Flexion	65 to 185 degrees	normal
Extension	normal	normal
Knee	180 to 140 degrees	180 to 140 degrees
Ankle and subastragalar	normal	normal

The patient was discharged on December 19, 1941. He went to work at once as a typewriter repairman.

This case illustrates the danger of distraction in the anatomic splint, and the slow return of knee motion in a man with multiple fractures.

CASE 3. A. C. W., retired, aged eighty-three years, was admitted January 23, 1942, suffering from a simple spiral fracture of the upper third of the shaft of the right femur (Fig. 3-A), shock, and generalized hypertrophic arthritis.

This patient had missed his step in the dark at home, and had fallen two hours previously.

On admission he was given plasma transfusion and supporting treatment. With local anaesthesia the fracture was reduced in the anatomic splint under the fluoroscope. The upper half-pin unit was inserted in the usual manner, and a third pin was inserted in the anteroposterior direction through the greater trochanter for added security. Plaster fixation was used. Roentgenograms taken after reduction showed the fixation pins and cast in place (Fig. 3-B). The next day he was up in a chair.

On February 10, 1942, he was replaced in the anatomic splint, the fracture was impacted, and a new plaster was applied. There was some superficial infection about the three upper pins. His generalized arthritis prohibited walking until April 2, 1942, on which date he commenced walking with crutches and assistance. An ulceration of the buttocks developed where the third half-pin caused pressure between its point and the skin. Some drainage about all these upper pins was noted. The third pin was removed on April 17, 1942, and on May 6, 1942, all other pins and the plaster were removed. There was clinical and roentgenographic union (Fig. 3-C).

On May 25, 1942, he walked up and down the ward with crutches. The arthritis continued to be troublesome. On June 23 he walked a few steps without support. His knee motion ranged from 180 to 135 degrees. Roentgenograms taken July 3, 1942, showed good callus and position (Fig. 3-D).

August 1, he was walking without any support, although his generalized arthritis was still quite troublesome. On September 1, the hip and ankle motions were normal. Motion in both knees was restricted a few degrees by his arthritis.

He was discharged September 4, 1942.

FIG. 3-A

Case 3. H. C. W. January 23, 1942. Roentgenogram taken on admission shows spiral fracture of the upper third of the shaft.

FIG. 3-B

January 23, 1942. Showing reduction of fracture.

FIG. 3-C

May 2, 1942. Roentgenogram, taken fourteen weeks after reduction, shows union.

FIG. 3-D

July 3, 1942. The fracture is healed five and one-half months after injury.

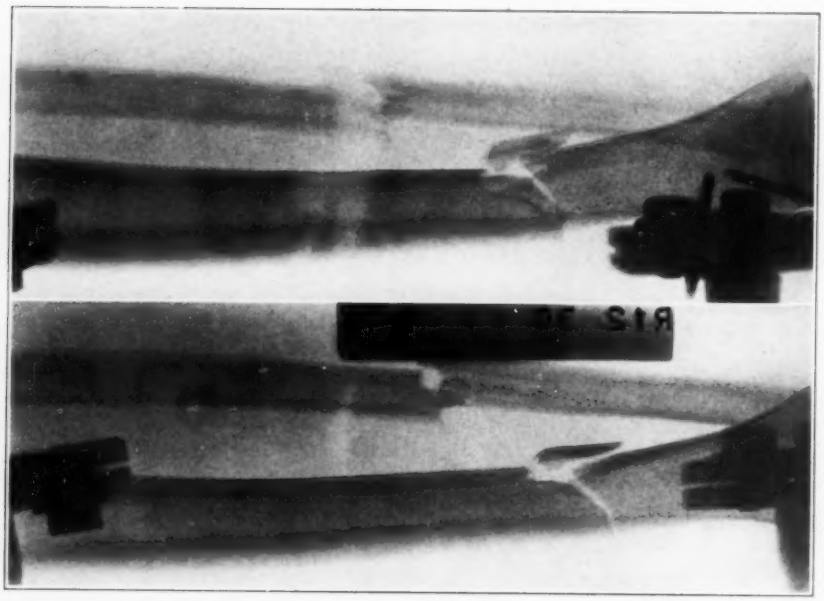

FIG. 4-B

December 30, 1941. Lateral views thirteen days after injury show motion at the fracture site. With the foot dorsiflexed there is good alignment.

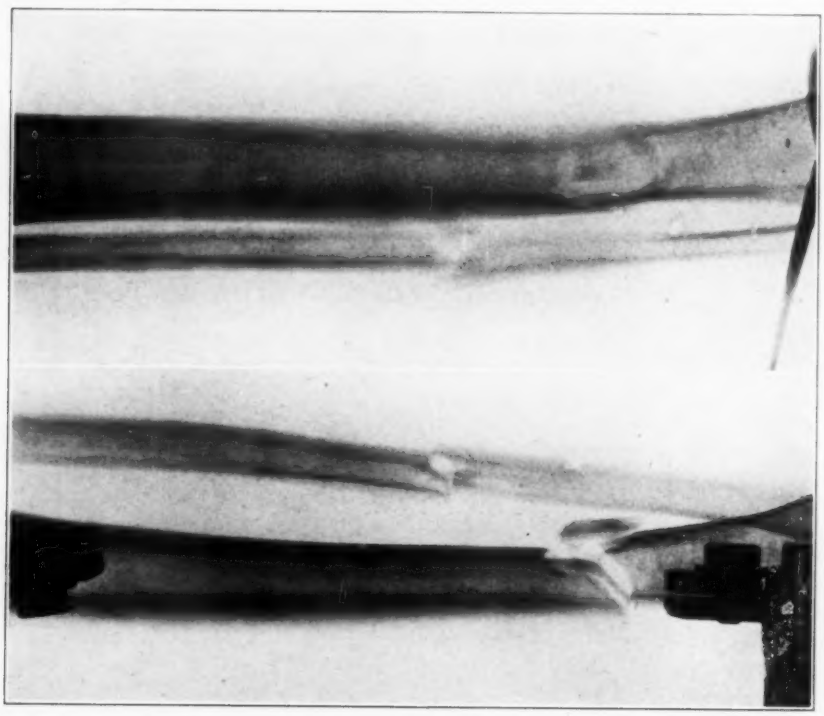

FIG. 4-A

Case 4. G. B. December 19, 1941. Roentgenograms taken after reduction, showing alignment.

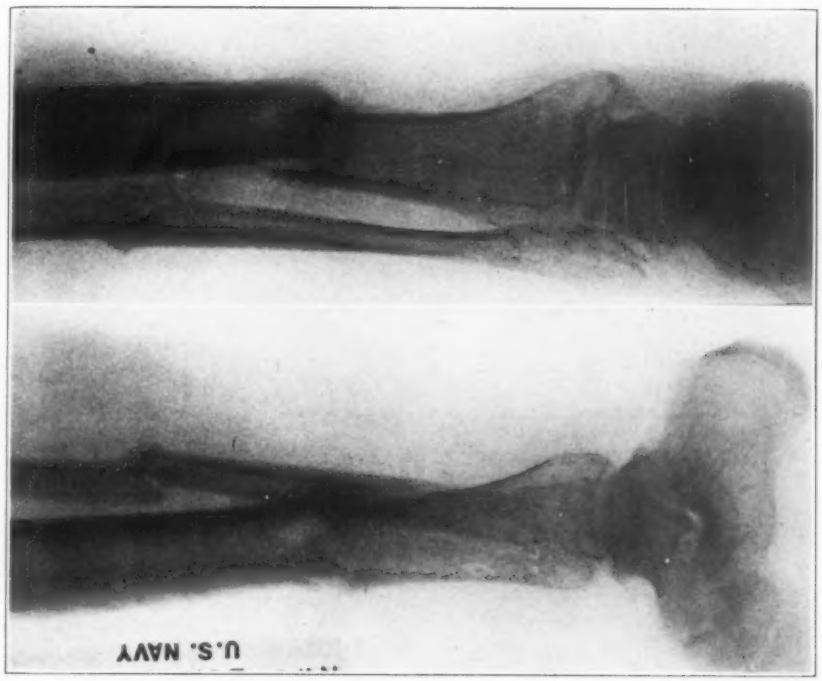

FIG. 4-D

March 20, 1942. Three months after injury there is good callus formation, but some eversion of the ankle.

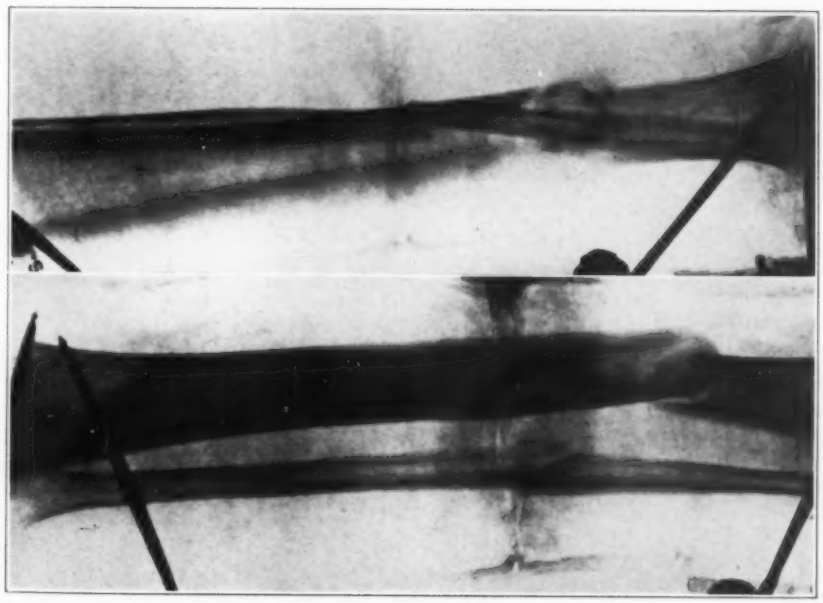

FIG. 4-C

January 21, 1942. Showing an increased medial angulation of the fragments and worse position following the removal of a circular strip of plaster and impaction.

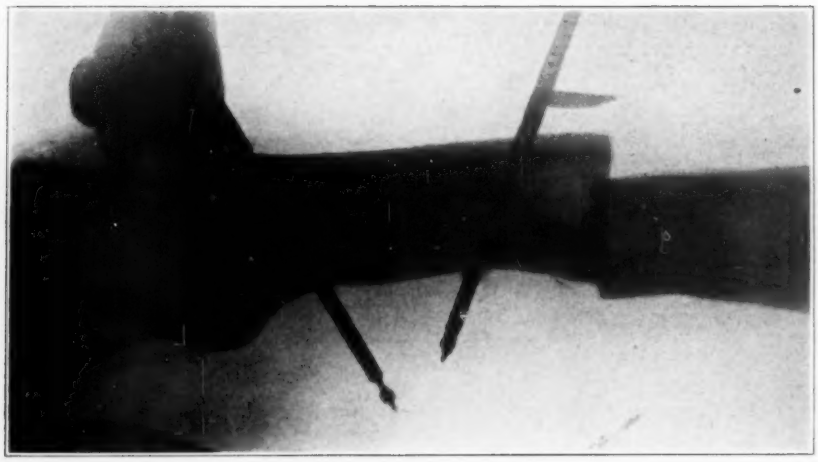

FIG. 5-C

May 12, 1942. The pins have been reinserted and there is satisfactory alignment.

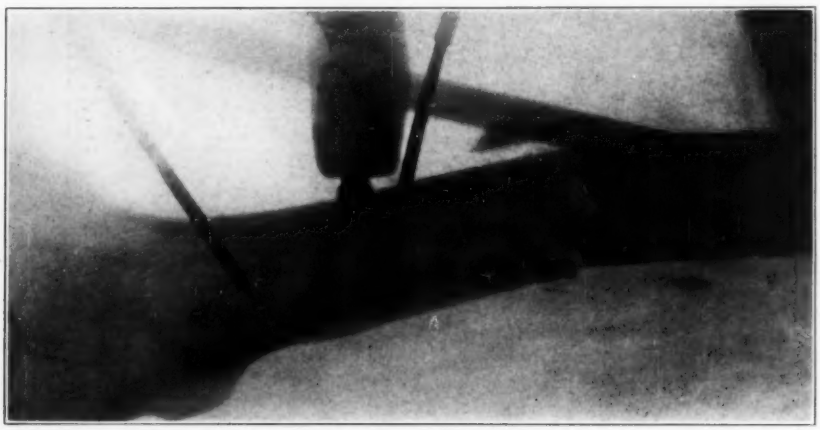

FIG. 5-B

May 9, 1942. The pins have failed to penetrate the second cortex.

FIG. 5-A

Case 5. C. L. C. May 1, 1942. Admission roentgenogram shows fracture of left femur.

FIG. 5-D

July 20, 1942. Good callus is evident.

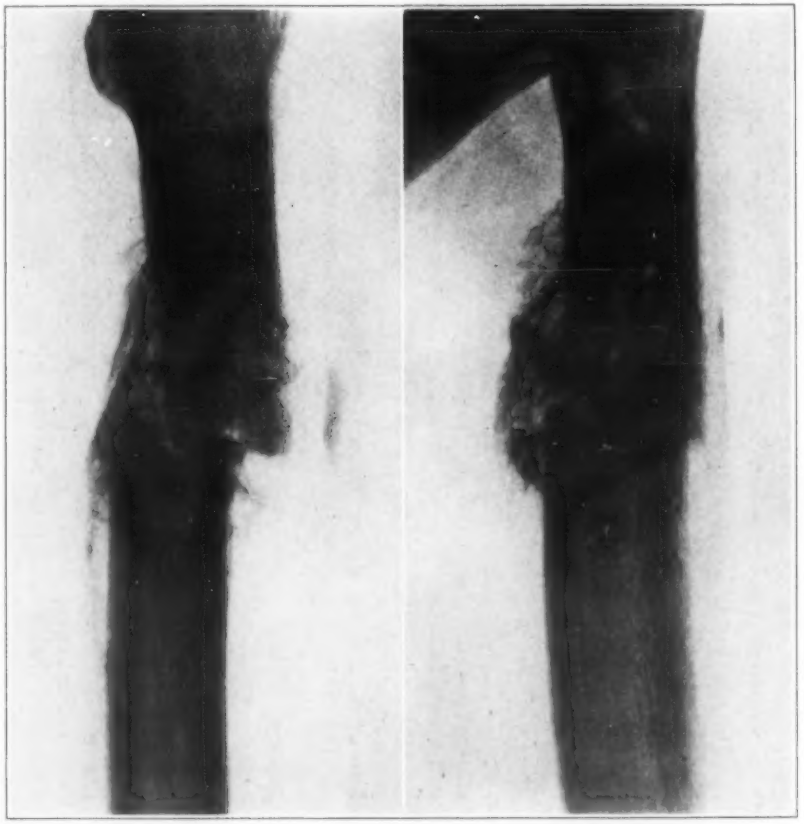

FIG. 5-E

August 26, 1942. Showing union seventeen weeks after injury.

This case illustrates the possibility of getting a man, eighty-three years old, out of bed the day following reduction. It also shows the danger of inserting the third pin in the anteroposterior diameter too deeply. In this thin individual, the point irritated the soft tissues of the buttocks and caused ulceration.

CASE 4. G. B., a W.P.A. laborer, aged fifty-one years, was admitted December 17, 1941, with a compound fracture of the lower third of the right tibia and fibula. Two days before admission the patient had been struck by an automobile, sustaining a compound fracture of both bones of the right leg. At another hospital the wound had been closed, and a long leg plaster had been applied. The patient had then been transferred to this Hospital. Roentgenograms showed a transverse fracture of the tibia and a higher oblique fracture of the fibula.

Two days after admission, fixation by the Roger Anderson half-pin units was done under spinal anaesthesia with fluoroscopic control. The units were united by double bars (Fig. 4-A). The patient had an uncomplicated postoperative course. However, he complained that there was a clicking at the fracture site when he moved the leg, and crepitus was felt. Roentgenograms taken December 30, 1941 (Fig. 4-B), showed a change in the relationship of the fragments of the tibia in the lateral views as the foot was dorsiflexed and plantar flexed. In other words, complete immobilization by means of the bar fixation had not been accomplished.

On December 31, 1941, the patient was replaced in the anatomic splint, the optimum position was obtained, and plaster fixation was substituted for the bars. The position was still not anatomically correct, but immobilization was complete.

On January 21, 1942, a circular strip was removed from the center of the plaster, and the fracture was impacted. Roentgenograms taken following this procedure showed the position to be worse (Fig. 4-C). There was medial angulation of the fragments and slight overriding. The patient was discharged January 29, 1942, walking with crutches, but without weight-bearing.

On March 20, 1942, the plaster and pins were removed. There was no infection and there was clinical union. A plaster boot was applied. Roentgenograms showed good callus.

This case illustrates the failure to obtain complete immobilization with the bar in a case of very low tibial fracture, because of the elasticity of the pins. It also demonstrates the inadvisability of trying to obtain too much impaction.

CASE 5. C. L. C., an aviation pilot, aged thirty-three years, was admitted May 1, 1942, suffering from a simple fracture of the left femur at the junction of the upper and middle thirds, a compound fracture of the right tibia and fibula, laceration of the right arm, laceration of the right eyelid, shock, and hemorrhage.

The patient had received the injuries in an airplane crack-up. He was brought to the Hospital in double Thomas splints, and taken at once to the operating room. His right arm and right eyelid were sutured, and a plaster-of-Paris splint was applied to the right leg from toes to groin. A Steinmann pin was inserted through the lower end of the left femur, and ten pounds of traction was applied. Plasma and whole-blood transfusion, and intravenous glucose were given. Reduction of the fractured femur was deemed undesirable at this time because of his poor general condition. Figure 5-A shows the femoral fracture on admission.

On May 6, 1942, his condition was sufficiently improved to permit reduction of the femur in the anatomic splint with a half-pin unit above, and two Steinmann pins through the lower end; double-bar fixation was applied.

Postoperative roentgenogram, taken May 9, 1942, shows the fragments of the left

FIG. 6-A

Case 6. W. J. W. Postreduction roentgenogram showing good alignment with pins inserted too close to the fracture.

FIG. 6-B

FIG. 6-C

February 17, 1942. Ten and one-half months after injury roentgenograms show union of both fractures.

femur in end-to-end apposition with excellent alignment, although the superior pins did not penetrate the medial cortex (Fig. 5-B).

Despite the absence of fixation, he was up in a chair on May 10, 1942, because of the fear of pneumonitis. On May 11, 1942, reduction was obtained by reinsertion of the superior half-pin unit (Fig. 5-C). He was up in the chair again the next day.

Roentgenograms taken on May 12, showed the pins in the corrected and satisfactory position. Some drainage appeared about the upper pins a week later, and he had some pain about them occasionally. On July 20, 1942, he commenced walking with crutches, and a rubber heel on the right leg. There was good callus and clinical union (Fig. 5-D).

On August 17, 1942, all fixation was removed from the left thigh. On August 26, 1942, there was firm clinical and roentgenographic union (Fig. 5-E).

The patient was walking in an ischial caliper brace, and fretting to get back into the War. There was 90 degrees of motion in the right knee, and 45 degrees in the left knee.

This case illustrates the necessity for being certain that both cortices have been penetrated by the half-pins.

CASE 6. W. J. W., an electrician, aged forty-two years, was admitted April 1, 1941, with an extracapsular fracture of the neck of the femur and a fracture of the shaft at the junction of the middle and lower thirds of the left femur.

Six hours before admission, a timber had given way and had knocked him to the ground, momentarily unconscious. He recovered quickly, but was unable to rise. He was brought in, in a Thomas splint, with an obvious fracture of the shaft of the left femur, and an extracapsular fracture of the femoral neck. Roentgenograms showed one and one-half inches of overriding, and posterior angulation of 15 degrees. Unfortunately, the admission roentgenograms have been lost.

Immediate insertion of the half-pin units and reduction in the anatomic splint were done. The thigh was then abducted and the neck impacted with a mallet. A plaster spica was applied from the nipple to just above the left knee. Figure 6-A shows the reduction of the fracture of the shaft, and the pins inserted far from the metaphyses.

Quadriceps exercise was started the next day; he was up in a chair on the fourth day and walked with crutches the sixth day. There was 25 degrees of knee motion at that time. Oedema of the leg then developed so that on May 6, 1941, the plaster had to be split on the anterior surface of the thigh; a fixation bar was applied.

On May 9, 1941, there was 30 degrees of knee motion, and some irritation about the lower pins had developed. On July 25, 1941, the bar was removed and a roentgenogram was taken. Motion was found at the fracture site and the bar was replaced.

On August 20, 1941, the pins were removed. Roentgenograms showed good callus. The patient was allowed up on crutches without weight-bearing. At this time, twenty weeks after trauma, there was no internal rotation of the left hip; there was 70 degrees of flexion, abduction to two-thirds of normal, and knee motion from 145 to 175 degrees.

On August 30, 1941, the patient was discharged walking with a cane. Later he returned for follow-up, walking with limp and cane. He complained of pain in the right sacro-iliac region in damp weather. The legs were equal in length. There was a lack of 15 degrees of internal rotation, and a lack of 20 degrees of flexion of the left hip. There was some atrophy of the left thigh and some quadriceps weakness.

The patient returned again for follow-up on February 17, 1942, at which time roentgenograms showed excellent position and union of both fractures (Figs. 6-B and 6-C).

On June 10, 1942, he was not working because he still had some arthritic pain in the lower back and right sacro-iliac region. Internal rotation still lacked 15 degrees; hip motion was otherwise normal as was knee motion. He walked with a slight limp on the left side.

It is noticeable in this case that in spite of the introduction of the half-pins into the diaphysis near the fracture, and the complicating neck

FIG. 7-A

Case 7. A. W. March 29, 1941. Roentgenograms taken on admission show fracture of both bones of the leg.

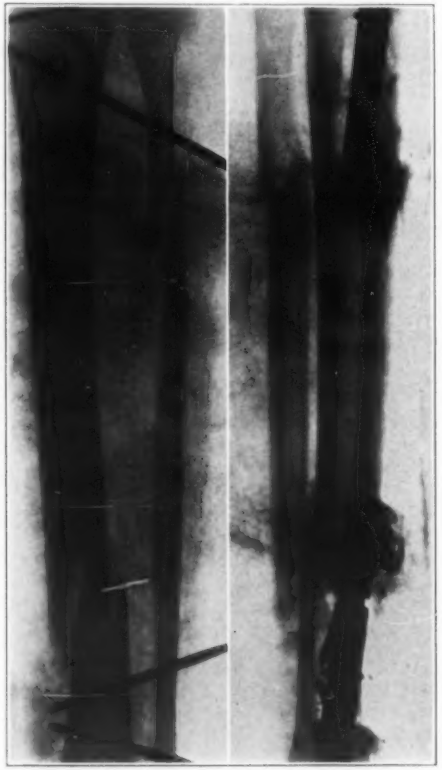

FIG. 7-B

March 31, 1941. Postreduction roentgenograms show alignment.

FIG. 7-C

October 8, 1941. Six and one-half months after injury the fractures are healed, but rarefaction has persisted about the upper pin hole.

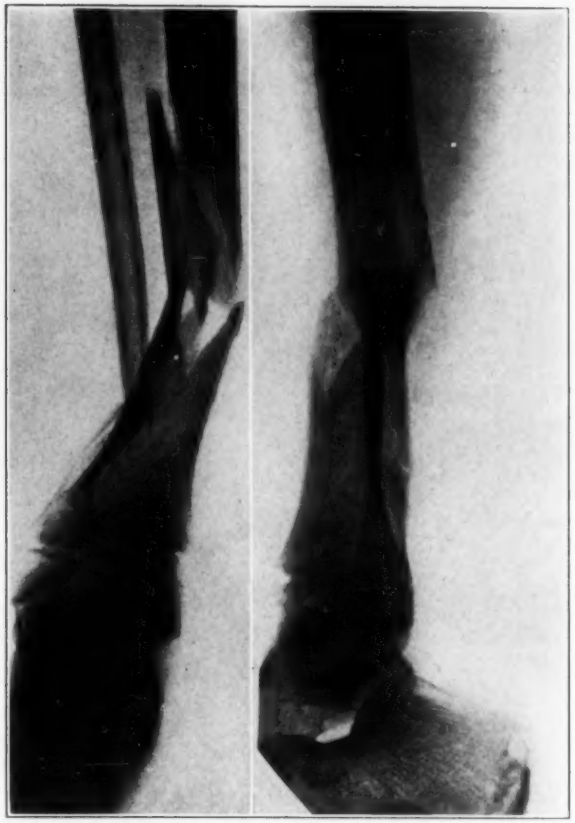

FIG. 8-A

Case 8. O. P. March 17, 1942. Fracture of both bones of the leg.

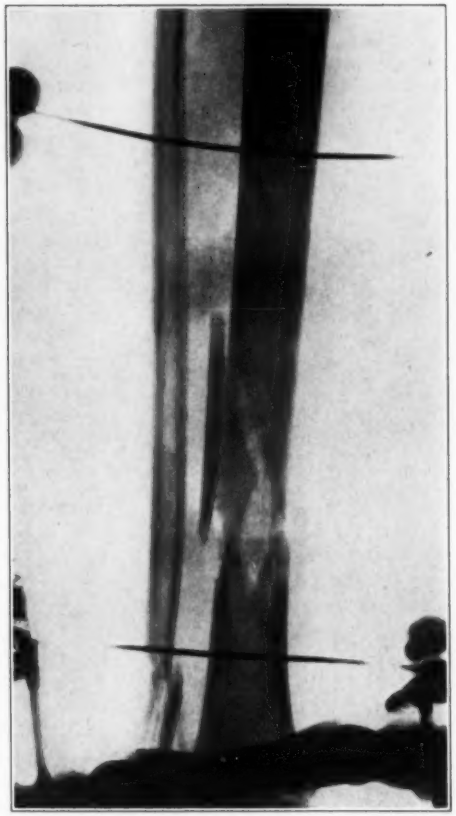

FIG. 8-B

March 18, 1942. Postreduction roentgenogram shows alignment.

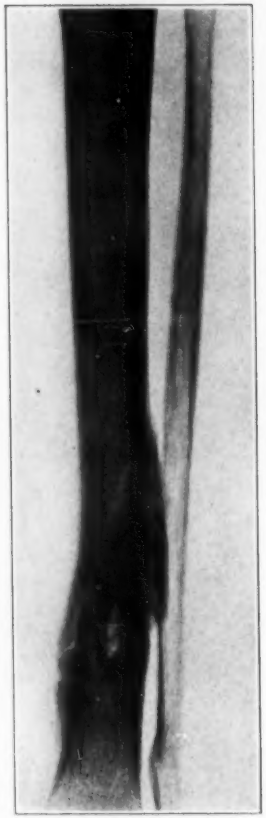

FIG. 8-C

July 1, 1942. The fracture has healed three and one-half months following injury.

fracture, the satisfactory reduction and fixation obtained by both plaster and bar enabled the patient to be out of bed on the fourth day, and up on the sixth, and resulted in excellent union of both fractures.

CASE 7. A. W., a school boy, aged fourteen, was admitted March 29, 1941, suffering from a simple spiral fracture of the left tibia and fibula (Fig. 7-A), which had been incurred while playing football three hours before admission. He arrived in a leg plaster, and was taken to the operating room at once.

Under spinal anaesthesia, the half-pin units were inserted, and the fracture was reduced under the fluoroscope (Fig. 7-B). He remained in the hospital overnight and commenced walking the second day. A month later, a little drainage was noted about the upper pin.

On June 17, 1941, pins and plaster were removed. Union was solid clinically and roentgenographically. He was cautioned to be careful for another month. Unrestricted activity was then allowed despite continuance of a little serous discharge from the upper pin hole.

On October 8, 1941, roentgenograms showed persistence of a little rarefaction about this pin hole (Fig. 7-C). The patient was last seen on April 4, 1942, at which time he still had occasional spotting from intermittent discharge from this pin hole.

This case illustrates:

1. The shortness of hospitalization necessary,
2. The ability to bear weight on the extremity quickly,
3. The rare instance in which drainage from a pin hole persists for months.

CASE 8. O. P., a school boy, aged nine, was admitted March 18, 1942, suffering from a compound comminuted fracture of the right tibia and fibula at the junction of the middle and lower thirds (Fig. 8-A). The patient had been struck by an automobile. An immediate débridement was done and manual reduction under general anaesthesia was attempted by the author in another hospital but resulted in an unsatisfactory position. The patient, therefore, was brought to this Hospital. Under sodium pentothal anaesthesia, two Kirschner wires were inserted above and two below the fracture, and reduction in the anatomic splint under the fluoroscope was accomplished. Double-bar fixation was instituted, and a posterior molded plaster splint was applied to keep the patient from weight-bearing. The boy went home that afternoon.

Roentgenograms taken following the reduction and application of the Roger Anderson apparatus revealed perfect position (Fig. 8-B). Six weeks later the wires were removed and a plaster boot was applied, but no weight-bearing was allowed. At the end of nine weeks a walking boot was applied. This was retained for three weeks. All restraining apparatus was then discarded. The roentgenogram taken on July 1, 1942 shows excellent position and callus (Fig. 8-C).

This case demonstrates the ease with which a fracture of a type, both hard to reduce and difficult to hold in reduction may be handled in the anatomic splint. It again illustrates that lengthy hospitalization is unnecessary.

CASE 9. T. E., an Ensign, aged twenty-three, received a large gunshot wound of the right thigh, with considerable loss of substance (including four inches of the upper third of the femur), at Pearl Harbor on December 7, 1941. The wound had been excised, sulfanilamide had been implanted, vaseline-gauze pack had been introduced, and the fracture had been reduced in the anatomic splint. The length and alignment of the femur had been carefully preserved, and fixation had been obtained by a plaster encasement. About a month later the patient was evacuated to this country. The roent-

genograms showed the half-pins in place, plus a Thomas splint for transportation. Roentgenograms taken following remanipulation and application of plaster showed that length and alignment had been maintained.

This patient was not treated on the author's service, and his ultimate disposition is unknown, but he illustrates one of the great advantages which this splint possesses that none of the older methods can duplicate,—the maintenance of alignment and length during a long period of healing when a portion of the shaft is missing.

DISCUSSION

These case histories illustrate some of the errors which the surgeon may commit in using the anatomic splint, unless he is constantly on the alert. Most of them are technical errors which could and should have been avoided. The sterility of the metal and operative technique, the proper placing of the pins, the attainment of satisfactory reduction without distraction in various types of fractures, and adequate fixation are all matters which proper care and attention will control.

The superficial drainage about the pins appears to be unavoidable with motion of the joints above and below. It could undoubtedly be obviated by immobilizing the entire extremity, but that would defeat one of the purposes of the anatomic splint.

In one instance some bone change was observed following prolonged drainage (Case 7). The author believes this must be considered a mild infection. There was no systemic distress, however, and the boy led a perfectly normal life regardless of it.

In another case (Case 4), there was inadequate fixation by the metal bar of a fracture of both bones of the leg just above the ankle. Immobilization of the ankle corrected this. These are the only instances in which any complications can be ascribed to a fault of the method or apparatus.

The author has not had any personal opportunity to use the anatomic splint in instances in which there were badly infected wounds. It has been used with gratifying results in spiral fractures of the femoral shaft where the author felt, as does Wilson, that plaster immobilization would be inadequate. It has also been used in supracondylar fractures of the femur which had to be unlocked before they could be reduced.

The author has been delighted with the ease in the handling of patients in this splint. The problems of evacuating patients to other hospitals and to air-raid shelters have been considerably simplified by not having them tied to the bed.

A number of rules for guidance in using the anatomic splint should be stressed. Most of these have already been indicated by Anderson.

1. Locate the position of the fragments by probing with Kirschner wires before inserting the pins.
2. Pierce through and beyond the second cortex with the pins.
3. Unlock fragments before trying to reduce the fracture.

4. Obtain end-to-end contact.

5. Verify position by roentgenogram before fixing with plaster or bar.

6. Avoid excessive traction with separation of fragments (distraction).

7. Release all traction before applying fixation.

8. Incorporate pins firmly in the plaster or with the bars.

9. Follow progress with roentgenographic check-up.

10. Keep fingers and sticks out of the cast.

11. Refrain from dressing and inspecting the pin wounds.

12. Leave pins in until callus is shown roentgenographically.

13. Protect callus when pins are removed.

14. Be cautious about too early weight-bearing in spiral and oblique fractures. Some motion at the fracture site is possible because of the elasticity of pins and bars (Case 4).

15. Insist on early and daily motion and exercise.

16. Insert pins in metaphysis.

17. When impacting spiral and oblique fractures, do not be too enthusiastic (Case 4).

The author wishes to emphasize Bradford's statement that the surgeon must learn to use the splint properly.

CONCLUSIONS

It is felt that the anatomic splint is not a panacea, but that it is an important addition to the armamentarium of fracture equipment. Its advantages have been enumerated by Bradford and Wilson, and by its originator. Its particular forte in military surgery is that it enables the patients to get out of bed almost at once, allows them to be evacuated readily, maintains length and position where there is loss of bone substance, and permits wounds to be dressed without disturbing the fracture.

The anatomic splint is not a complicated machine, and its use can be readily mastered by one trained in the mechanics of any of the numerous mechanical-reduction units. The new interchangeable units which have been recently introduced by Anderson to replace the rigid half-pin units simplify its use still further.* The latitude which they allow in the placement of the pins, and the ease with which fixation can be obtained with the new clamps and rods is a considerable improvement over the old half-pin units. The author believes it marks an advance in technique which will render the Anderson method still more adaptable in the treatment of high, oblique fractures of the femoral shaft. These new pins also offer a simpler means of controlling a loose third fragment, which has always been such a difficult problem. However, it is necessary to learn to use this splint correctly. One cannot be in a hurry.

* Since the submission of this paper for publication, the author has used these new units on thirty-six cases and is greatly pleased by the latitude which the newer technique allows in the placement of the pins. He has used as many as six pins in some instances to secure fixation of detached fragments.

Asepsis must be maintained. The anatomic splint is, therefore, not a device which can be properly used in first-aid or battle-dressing stations, or in casualty-clearing stations close to the line of battle. Nor can it be safely employed by one not experienced in the treatment of fractures.

The importance of not distracting the fragments by overextension cannot be overemphasized. The author has been able to obtain knee motion of about 25 degrees at once with this splint, but has not been able to obtain any marked increase of knee motion until the pins have been removed. There is usually some pain and a little discharge about the pins, but this does not mean infection.

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A METHOD OF REDUCING FRACTURE-DISLOCATIONS OF THE CERVICAL VERTEBRAE

With a Report of Two Illustrative Cases

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The standard methods at present in use for reduction of fractures of the cervical vertebrae are various forms of traction. Cone and Turner have used skeletal traction and fusion, and this is an excellent method for recurrent cases. Crutchfield also advocates skeletal traction, especially when the fracture is associated with nerve lesions. The methods of manual traction are the Taylor technique, applied by means of a sling around the jaw and occiput, or the Walton manoeuvre of manual traction and rotation of the head to the opposite side. For the application of a plaster cast after reduction by any one of these methods, the patient has to be held manually, or placed on a table with a projection such as those used by Böhler, or Watson-Jones. In order to minimize movement and simplify the procedure, the following method of reduction by leverage is suggested. The fundamental principles involved are the use of a firm support for the head during reduction, and the application of a plaster cast without moving the patient.

The equipment needed in using this method is a metal support, twenty-five inches long by five inches wide at one end, and tapering to a width of three inches at the other end. The broad end is clamped to the operating table so that the support, which is suitably padded, projects for a distance of eighteen inches (Figs. 1-A and 1-B). The patient is carefully placed in the supine position on the table, with the head just overhanging the padded, tapered end of the projecting "board". The shoulders are firmly secured in supports which serve as countertraction during manipulation. These must be extended beyond the end of the table to correspond with the position of the head (Fig. 2).

In the average adult, the distance of the symphysis menti from the occiput is eighteen to twenty-one centimeters, while the occipito-atlantal joint is eight to nine centimeters from the external occipital protuberance. With the end of the metal support placed just under the external occipital protuberance, approximately six to seven centimeters from the occipito-atlantal joint, this distance is reduced by two centimeters and thus the mechanical advantage obtained by leverage is three to one. In levers of these proportions, when the handle is moved through three centimeters, the weight is raised one centimeter, while each pound of force exerted results in three pounds of traction.

Using the occiput as a fulcrum and the jaw as a lever, pressure is applied to the point of the jaw and the head is gradually tilted backward until the hyperextended position is obtained. This movement raises the

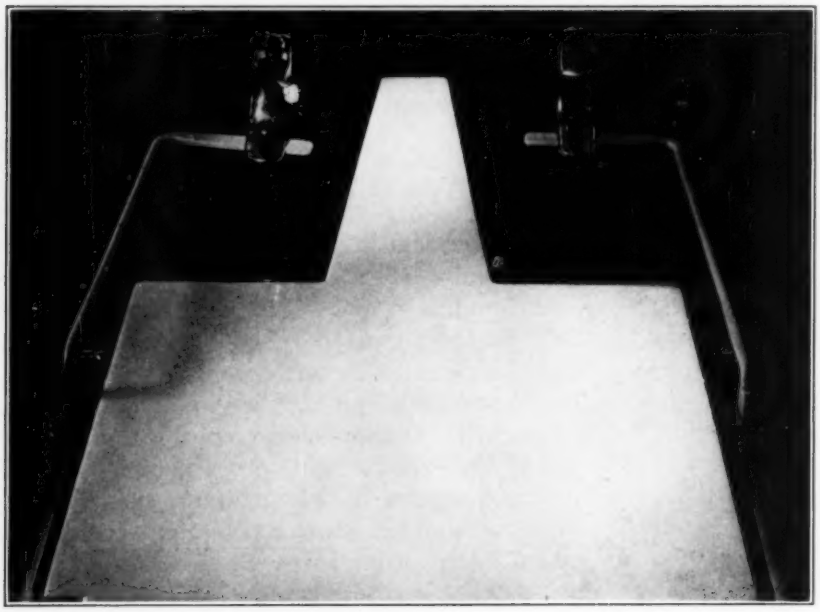

FIG. 1-A

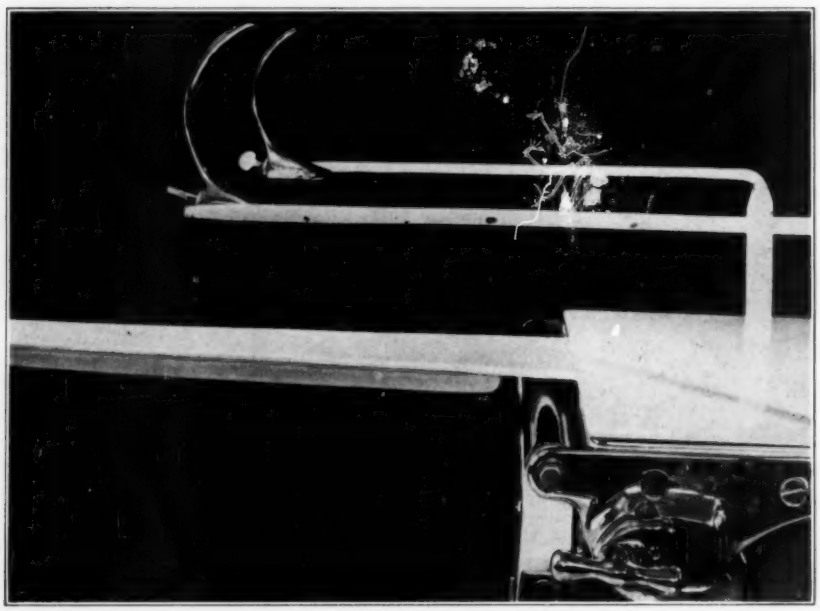

FIG. 1-B

The metal "ironing board" showing the shoulder supports.

upper fragment, disimpacts the compression fracture, and corrects the dislocation, leaving the contour of the neck in the gentle curve of correct alignment (Fig. 3). By using this method, it is possible to reduce fractures of the cervical vertebrae safely and steadily, and one may stop at any time for a roentgenogram, as all movement is controlled, because the occiput is held in constant position by the support. The operator may stand on either side or at the head of the patient, depending upon his custom or the particular needs of the individual case. Stability supplied by the fulcrum allows fine adjustments to be made with complete control throughout the procedure.

When reduction has been satisfactorily obtained, as revealed by roentgenographic examination, the patient is already in the desired position for the plaster cast, which may be applied without further movement or delay. The cast is carried from the top of the head to the middle of the thorax; then, with the fracture securely encased in plaster-of-Paris, the patient may be moved horizontally along the table until the buttocks are at its edge, the back being supported by a stool. The "ironing board", which has now served its dual purpose, is removed, and the cast is completed to enclose the pelvic girdle.

If this equipment is not available, a wooden substitute may be used. It is made from a piece of wood six feet long by six inches wide by three-quarters of an inch thick (such as five-ply wood), with one end tapered to a width of three inches. This may be placed on any suitable table so that the tapered end projects eighteen inches, and the patient may be laid upon

FIG. 2

Reduction by leverage, using the metal "ironing board" and extended shoulder supports.

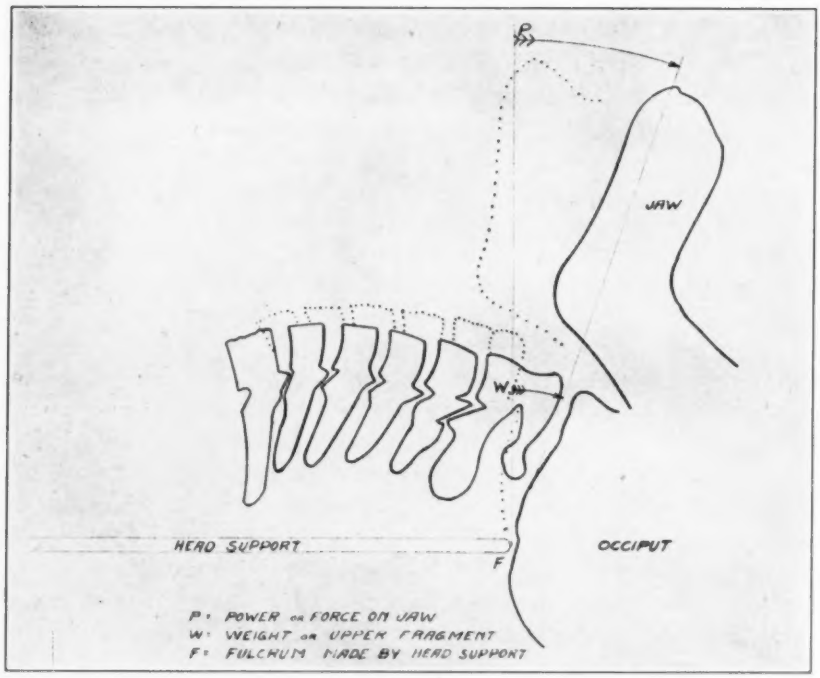

FIG. 3

A diagrammatic representation of the theory of reduction by leverage. The dotted lines show the position before reduction, and the continuous lines, the restoration of normal contour.

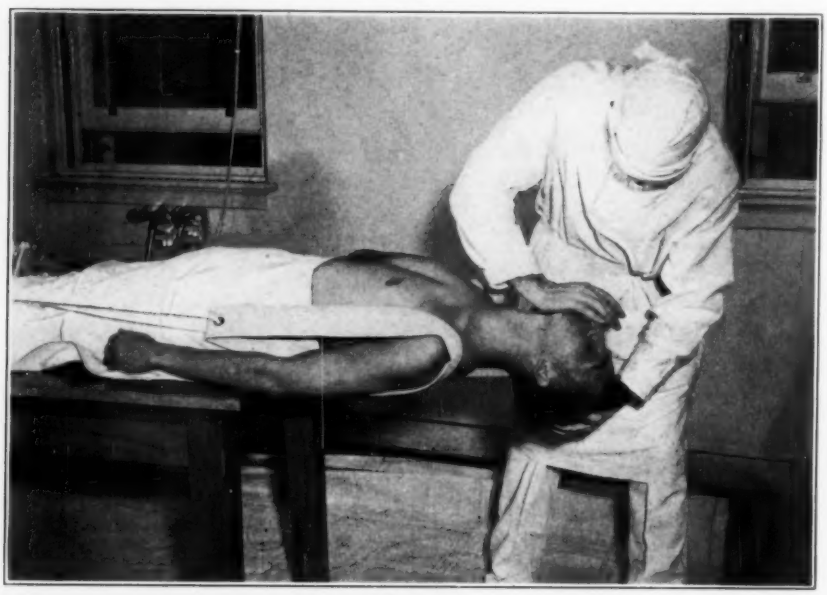

FIG. 4

Reduction by leverage, using the wooden "ironing board" with canvas shoulder straps.

it as already described. The other end may be clamped, or held down by means of sandbags; and shoulder slings may be improvised from any suitable material and anchored around the legs of the table (Fig. 4). Reduction and application of the plaster cast are carried out as before. This improvised apparatus was used in one of the cases reported herein.

The first case to illustrate the use of this method was a fracture of the axis caused by an automobile accident.

A naval rating (J. S.), aged thirty-eight, was admitted to hospital February 14, 1942, with multiple cuts of the face and in considerable shock. After the shock had been treated, a roentgenogram of the neck was taken and, according to Dr. H. H. Murphy's report, showed a fracture "through the laminae and body of the second cervical vertebra, involving the base of the odontoid process, with forward dislocation of the first cervical vertebra on the second. The odontoid process is carried forward

FIG. 5-A

Anteroposterior view of the axis taken through the open mouth showing fracture of the body.

FIG. 5-B

FIG. 5-C

Fig. 5-B: Lateral view of neck showing anterior angular deformity of axis and separation of posterior arch of atlas from spine of axis.
Fig. 5-C: Position after reduction by leverage.

FIG. 6-A

FIG. 6-B

Fig. 6-A: Lateral view of the neck showing compression fracture of the body of the seventh cervical vertebra with bilateral dislocation.
Fig. 6-B: Lateral view of neck with dislocation partially reduced.

FIG. 6-C

Restoration of normal alignment by leverage.

with the first cervical vertebra, suggesting that the transverse ligament has remained intact" (Figs. 5-A and 5-B).

In view of the patient's condition, the situation of the fracture, and the amount of displacement, no anaesthetic was given, as it was feared that even a local anaesthetic might relax the muscles and allow the odontoid process to press on the medulla. A sling was used, and traction was applied in the long axis of the body; this was followed by hyperextension produced with one hand on the spinous process and the other pressing the chin backward. A roentgenogram was then taken and showed that reduction was not satisfactory. It appeared that if the occiput could be held firmly and pressure applied to the chin in a backward direction, the resulting leverage should produce the necessary reduction of the bone deformity. A wooden support was placed in position and held between the end of the table and the occiput. Using two hands and part of the body weight, firm steady pressure was applied to the patient's chin in a downward and backward direction. A second roentgenogram showed the bones restored to their normal alignment. The roentgenographic report was as follows:

"The fracture through the body of the axis with displacement forward of the odontoid process has been reduced, and the widening of the space between the posterior neural arch of the atlas and that of the axis previously demonstrated is now within the limits of normal—a very excellent result" (Fig. 5-C).

A plaster cast was immediately applied from the top of the head to the pelvis. This was worn for three months, the patient doing exercises during the last two months. The roentgenogram, taken after removal of the cast, showed that the correct alignment had been maintained. A Thomas collar was fitted, and exercises with the full range of neck movements were carried out regularly. Six months from the time of injury he was able to return to duty, symptomless and with firm bony union.

The second case occurred less than six weeks later, and was due to diving from a height of twelve feet and striking a rubber tire with the head flexed.

This naval rating (G. B. E.), aged twenty-six years, gave a history of temporary loss of function of the legs, but, on examination twenty minutes after injury, he was able to move both arms and legs normally. The slightest movement of the head or neck caused pain at the back of the root of the neck, and tenderness was elicited in an area four inches in diameter around the vertebra prominens. A diagnosis of fracture of the seventh cervical vertebra was made, and confirmed by roentgenograms on admission to hospital. The roentgenographic report from Surgeon-Lieutenant Crysler was as follows:

"Stereoscopic films were made of the cervical spine. In these there is demonstrated a compression fracture of the seventh cervical vertebra, the compression amounting to approximately three millimeters. The sixth cervical vertebra is dislocated anteriorly on the seventh at both articular facets" (Fig. 6-A).

There was very little shock, and preparations were made for immediate reduction. In the operating room the patient was placed on the specially constructed "ironing board" and reduction was undertaken, using the method of leverage. Figure 6-B is a check roentgenogram taken during the manipulation. Pressure was again applied to the jaw, the position of hyperextension of the neck was increased, and complete reduction of both the dislocation and the fracture was obtained. The roentgenologist's report follows:

"A film made in the lateral direction after further manipulation reveals complete anatomical reduction of the dislocation. In addition, the compression is entirely reduced, so that the height of the seventh cervical vertebra has been completely restored" (Fig. 6-C).

A plaster cast was applied without change of position. This patient was allowed up after two weeks, but wore his cast for three months. A fitted Thomas collar was worn for a further three months, except during the regular periods of exercise. At the end of the six months he was returned to duty with no symptoms, full function, and firm union.

CONCLUSIONS

These two cases illustrate the reduction of fracture-dislocation at the upper and lower ends of the cervical vertebrae by the method of leverage. The distinctive feature of this method is the degree of control it affords, because the fixed support constantly steadies the neck, while leverage reduces the amount of force required to achieve reduction. The movement of the head around the fulcrum is the most direct route to the ultimate position; and elimination of all further movement before application of the cast makes the procedure simple, safe, and accurate. This method is suggested as a logical and efficacious treatment for fracture-dislocations of the cervical vertebrae.

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ARTHRITIS OF THE ACROMIOCLAVICULAR JOINT

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The clinical condition which has come to be designated as "painful shoulder syndrome" may be produced by different lesions, among which arthritis of the shoulder joint, bursitis, and neuralgia, due to disease of the cervical spine, are perhaps the most common. Arthritis of the acromioclavicular joint seems to induce this syndrome more frequently than the scant references in the literature[2, 3] would lead one to expect.

The acromioclavicular joint is an arthrodial (synovial) articulation with a fairly wide joint cavity sometimes containing a disc [1]; together with the sternoclavicular joint, it allows the scapula to slide along the thoracic cage during movements of the arm in the shoulder joint. Roentgenograms show that there is motion in the acromioclavicular joint during all movements of the humerus except rotation[4]. Therefore limited mobility in the acromioclavicular joint interferes with those movements of the arm in which the scapula takes active part,—such as thrusting and swinging the arm forward, reaching and lifting an object above shoulder level, and moving the arm above the head, across the chest, or onto the back. Since these movements are also restricted in the presence of other lesions in and around the shoulder joint, as well as in the presence of radicular neuralgia, and since the degree and distribution of the pain are rarely characteristic of any particular lesion, a differential diagnosis cannot often be made purely on clinical grounds, and the roentgenographic findings are significant.

The acromioclavicular joint may be depicted in several roentgenographic projections[2, 3, 4], of which the simplest is a straight anteroposterior view with the patient upright, holding his shoulders back like a soldier standing at attention. The details of the various techniques and the roentgenographic findings are reported separately in more detail [4]. It is always useful to have roentgenograms made of both sides for comparison.

In healthy persons, the acromioclavicular joint space is seen as a transparent gap about one to three millimeters wide. The bony articular surfaces are clean-cut and may be straight, notched, concave, or convex; their shape may differ in the two joints of the same person. The articular capsule and ligaments cast a tubular or a slender, spindle-shaped shadow merging with the bony ends and not rising more than one millimeter above their levels in the region of the joint space. The articular and paraarticular bone has a conspicuously regular, meshy structure with a very thin cortical layer. Secondary centers of ossification and supernumerary ossicles, often present close to the sternoclavicular joints, were not seen at the acromioclavicular joints in a series of healthy subjects of all age groups, including young children and adolescents.

The acromioclavicular joints may be involved by tuberculous arthritis, rheumatoid arthritis, or osteo-arthritis. In a few patients suffering from systemic rheumatoid arthritis, alterations characteristic of this disease were found in the acromioclavicular joints. In these cases, the clinical findings suggested the presence of this lesion. But, in the much more common instances of acromioclavicular osteo-arthritis, the involvement of the acromioclavicular joint was not evident from the clinical signs and symptoms. In some of these patients, the joint capsule was found to be definitely enlarged, casting an olive-shaped or globular shadow; this was sometimes associated with narrowing of the joint space and slight eburnation of the articular surfaces (Fig. 1-C). In another group of cases, there was marginal overgrowth along the articular bones, with roughening of the joint surfaces, and widening of the joint space, probably caused by effusion. The structure of the subchondral bone had an irregular honeycombed appearance. Some of the patients stated that pain and limitation of movements had developed gradually after a trauma incurred weeks or months before; in others, the disabled shoulder had been subject to constant occupational strain. For instance, a right-handed schoolteacher who, being short, was obliged to strain the right arm in order to write on the blackboard, complained of "rheumatism" in the right shoulder, gradually increasing in severity. There was definite osteo-arthritis of the right acromioclavicular joint (Fig. 1-D) without evidence of any other disease of the shoulder joint, muscles, bursae, or cervical spine.

Irrespective of the kind of changes present, and whether or not the capsule or the articular bone was chiefly involved, the clinical manifestations were always the same. As already mentioned, the patients complained of pain in the shoulder, often radiating into the forearm and hand; of inability to carry out certain movements, especially combing the hair, lifting an object, or fastening a dress at the back; of pain at night which awakened them and forced them to find a more comfortable position; and of a feeling of fatigue. On physical examination, all of the movements of the shoulder joint, including rotation of the arm, were found to be definitely limited; pain was induced by both active and passive motion, and by pressure upon the deltoid, shoulder joint, and acromion. The pain was described as sharp, stabbing, or dull, and sometimes radiating to the neck and back. In some cases, the anterior projection of the acromion was particularly sensitive to pressure, but most of the patients were unable to state which part of the shoulder was especially painful on palpation. There was no rise of temperature in any of the patients; blood counts were generally normal; and the sedimentation rates were not increased. In two cases, the pain was severe enough to require large amounts of analgesics including morphine, which, however, did not bring much relief. In a number of patients the deltoid, biceps, and triceps muscles on the involved side were flabby and atrophic.

Lesions, to which pain in the shoulder is usually ascribed, may exist without causing any symptoms. For instance, calcified subdeltoid and

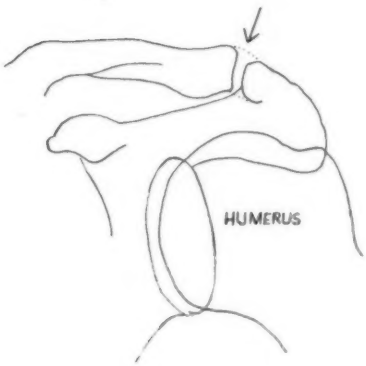

FIG. 1-A

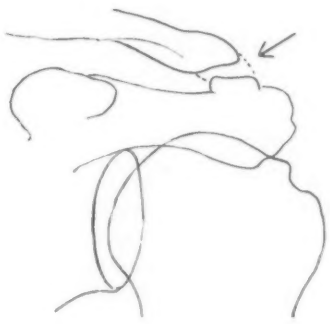

FIG. 1-B

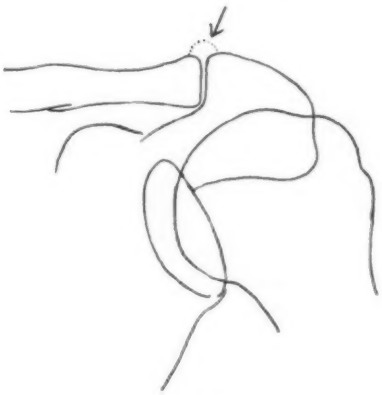

FIG. 1-C

FIG. 1-D

Tracings from roentgenograms of acromioclavicular joints in the straight anteroposterior projection. The dotted lines show the size and shape of the soft-tissue shadows cast by the capsule and the ligaments.

Figs. 1-A and 1-B: Normal joints.

Fig. 1-C: Acromioclavicular joint space strongly narrowed, with capsule enlarged, in a woman, fifty-nine years old, whose left shoulder was completely disabled.

Fig. 1-D: Roughness of the articular surfaces, with marginal osteophytes and swelling of the joint capsule, in a schoolteacher who complained of pain and disability of the right shoulder.

subacromial bursae, small osteophytes at the margins of the glenoid cavity, and thinning of cervical intervertebral discs, all of which lesions seem to produce clinical manifestations in many instances, are often discovered accidentally in the absence of clinical signs and symptoms. It is possible that acromioclavicular arthritis may be present without producing clinical manifestations, but the writer has not yet seen such an instance. None of the patients with lesions of this joint was free from pain in the shoulder, and, in a control series of healthy persons of various age groups, the acromioclavicular joints were found to be completely normal, although some of these persons had lesions of the shoulder joint and cervical spine without being conscious of them. The results of this control series seem to indicate that the lesions of the acromioclavicular joint here under discussion have clinical significance.

Untreated, the disease does not seem to subside. The movements of the shoulder become progressively restricted, and atrophy of the muscles of the shoulder girdle develops. Lack of sleep caused by the nocturnal pain makes the patients look fatigued and nervous. The pain has no tendency to subside, and sedatives gradually lose their effect.

All of the twenty-four patients of this series were referred to the author because the usual therapeutic measures, (which included radiant heat, hot packs, diathermy, and injections of a local anaesthetic into the deltoid muscle) had failed to produce more than temporary relief. After several unsuccessful attempts at controlling the pain by means of short-wave diathermy, roentgenotherapy was used (140 kilovolts, 20 milliamperes, one-half of a millimeter of copper plus one millimeter of aluminum filtration, at fifty centimeters' target skin distance). Through a portal five centimeters square, directed to the acromion from above, fifty roentgen units, measured in air, were given; and this treatment was repeated after an interval of five to seven days. In some of the patients, the pain began to subside very rapidly after the second treatment, and a normal range of movements of the shoulder was regained after two to three weeks. In other patients, whose symptoms had persisted for over five months previous to treatment, five to eight irradiations at intervals of about one week were necessary to bring about relief. Disappearance of pain was always followed by disappearance of the limitation of movements after two to four weeks. No other mode of therapy was applied, and the use of sedatives was discouraged. One patient was advised to carry the arm in a sling for several weeks; the others were permitted to move the arm and shoulder according to their own judgment. No ill effects of roentgenotherapy were observed; nor have recurrences been reported.

SUMMARY

Signs and symptoms conforming to the "painful shoulder syndrome" may be caused by arthritis of the acromioclavicular joint. In the author's cases, the clinical manifestations were indistinguishable from those produced by arthritis of the shoulder joint, subacromial and subdeltoid bursitis, and radicular neuralgia. Both the clinical and the roentgenographic findings suggested osteo-arthritis or traumatic arthritis. Roentgenotherapy in very small doses resulted in clinical cure in a series of patients. Other modes of treatment had not been effective.

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NEGLECTED FEMORAL FRACTURES *

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Fractures of the femur are a major problem in military surgery. A critical analysis of neglected cases is important.

Twenty have been selected from the cases of fractures of the femoral shaft admitted to the Walter Reed General Hospital during the last five years. These patients came from military and civilian hospitals in ten states scattered from Texas to Vermont. Seventeen of them were under thirty years of age. The time interval from injury to admission varied from one day to two years, three being admitted for treatment within one week, eight after from two to four weeks, eight after from two to six months, and one after twenty-six months.

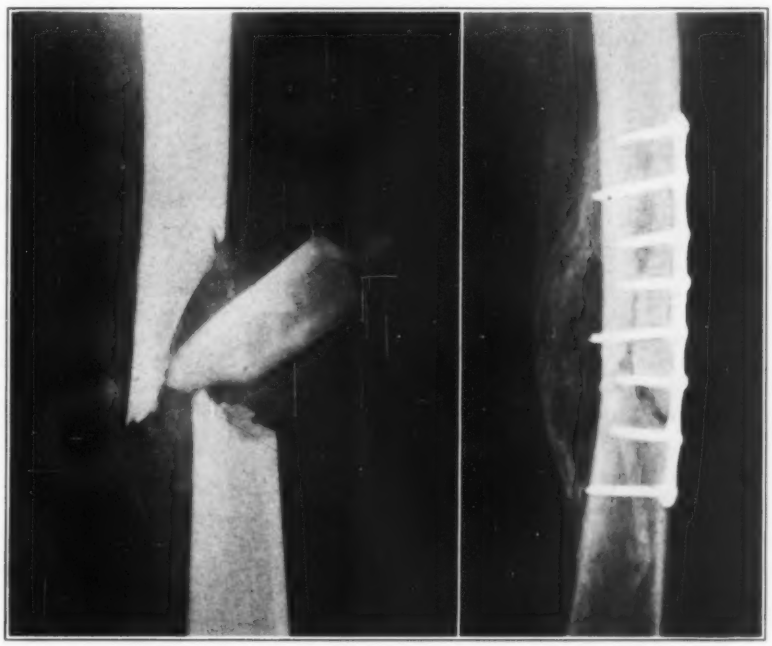

FIG. 1-A FIG. 1-B

Case 1. J. J. B. was admitted with a simple fracture incurred seventeen days before. A large fragment had rotated 135 degrees and appeared ready to pierce the skin (Fig. 1-A). Operation was imperative; the fragments were fixed with a plate and eight screws. Postoperative support with suspension traction permitted early knee motion, and result was satisfactory (Fig. 1-B).

Suspension traction is preferred to plaster immobilization in such a case.

* Presented at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 20, 1943.

FIG. 2-A

FIG. 2-B

Case 2. J. H. K. was admitted with multiple unreduced simple fractures of the femur which had occurred twelve days before, and which had been immobilized in a plaster cast (Fig. 2-A). This was successfully treated by suspension skeletal traction. Five months later a brace was applied. Seven months after injury he had solid bony union and 80 degrees of knee motion (Fig. 2-B).

This type of fracture does not respond well to dual-pin fixation, because the middle fragment cannot be controlled. If the traction used had failed, open reduction would have been necessary.

FIG. 3-A FIG. 3-B FIG. 3-C FIG. 3-D

Case 3. J. B. G. was admitted with a severely comminuted simple fracture with at least five large fragments. This had been unsuccessfully treated by skeletal traction (Fig. 3-A). Two weeks after injury it was fixed with a plate and nine screws (Fig. 3-B). Union was slow, and Figure 3-C (twelve months after injury) suggests aseptic necrosis of bone. The brace was removed after eighteen months (Fig. 3-D).

This case illustrates failure by traction and damage to blood supply by extensive operation.

FIG. 4-A

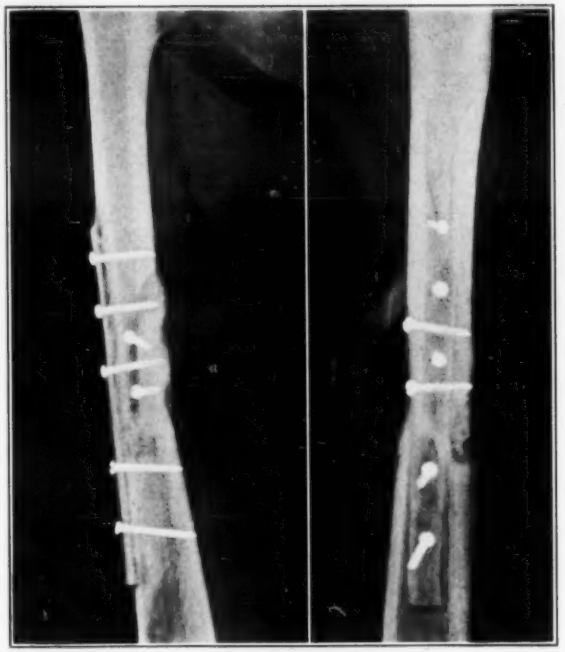

FIG. 4-B

Case 4. G. A. A. had suffered a simple fracture which had been treated with a Kirschner wire in each fragment and plaster immobilization. He was allowed to walk in the cast ten weeks after injury. A week later he was admitted with no evidence of union (Fig. 4-A). Bone grafting was done and resulted in union after four months (Fig. 4-B).

This case illustrates the inadequacy of wire fixation, the need for early open reduction and plating when there is a large displaced fragment, and the use of a bone graft instead of a plate three months after fracture.

FIG. 5-A FIG. 5-B FIG. 5-C

Case 5. J. H. P. was admitted with a simple fracture nineteen days old (Fig. 5-A). Suspension skeletal traction, which had been used before and was continued after admission, resulted in distraction and non-union (Fig. 5-B). Bone-grafting was done four months after the injury and resulted in firm union eight months later (Fig. 5-C).

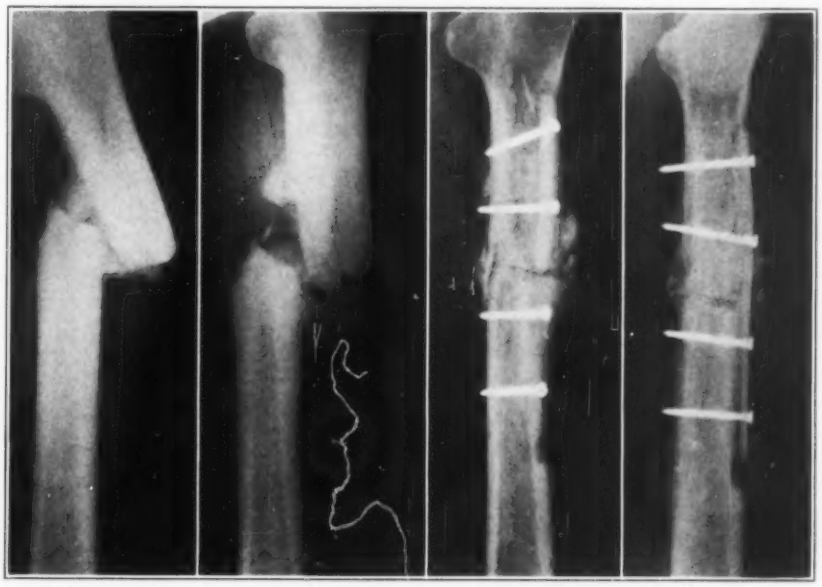

FIG. 6-A FIG. 6-B FIG. 6-C FIG. 6-D

Case 6. J. S., who had a simple fracture treated with skeletal traction, had been allowed not only active knee motion in five weeks, but to walk without a brace two months after injury. Upon admission one month later, the femur showed shortening of two inches (Fig. 6-A). The callus was broken by manipulation, and skeletal traction was reapplied. This corrected the deformity, but union was not obtained (Fig. 6-B), and bone-grafting became necessary five months later. After another five months, he was ambulatory with an ischial caliper brace (Fig. 6-D). (See page 876.)

In Case 6 (see page 875), motion had been allowed too soon after injury, and weight-bearing had been permitted before union was firm. Six months' protective treatment is generally required. Moreover, conservative treatment was probably continued too long before bone-grafting.

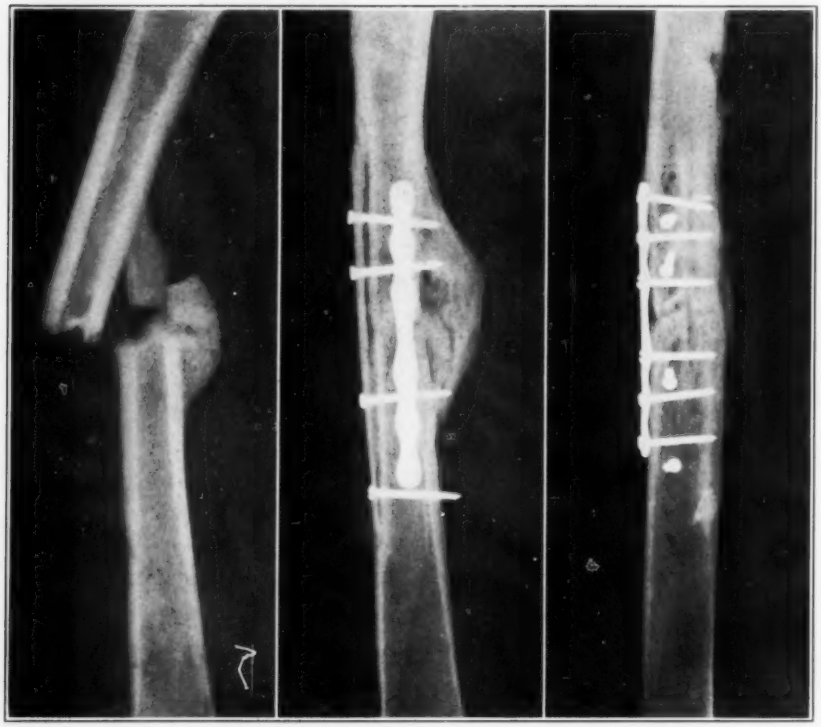

FIG. 7-A FIG. 7-B FIG. 7-C

Case 7. C. E. N. was admitted twelve days after a simple fracture which had been treated unsuccessfully with dual pins. The pins were removed and suspension skeletal traction was applied. Reduction was incomplete, and the insufficient callus broke (Fig. 7-A). Bone-grafting with a plate was done six months after injury. Seven months later union was firm. There was 110 degrees of knee motion and only a half inch of shortening (Figs. 7-B and 7-C).

This case illustrates failure not only of dual-pin reduction, but also of suspension traction, due in each instance to interposition of tissue. The plate gave firm support to the graft and permitted early knee motion.

Three of the fractures had originally been compound; four had had insertion of multiple pins and wires; and four had undergone operation before admission. These cases represented failure of treatment which may have been contra-indicated in the individual case, or which may have been improperly applied. The author offers this analysis as a criticism of the treatment, both before and after admission to this Service.

The cases here presented illustrate the common reasons for failure in the treatment of fractures of the femur,—inadequate immobilization, early and vigorous motion, or early unsupported weight-bearing. After definitive treatment, a rigid walking brace is advised until union is firm. Treatment by plaster without other fixation permits displacement and

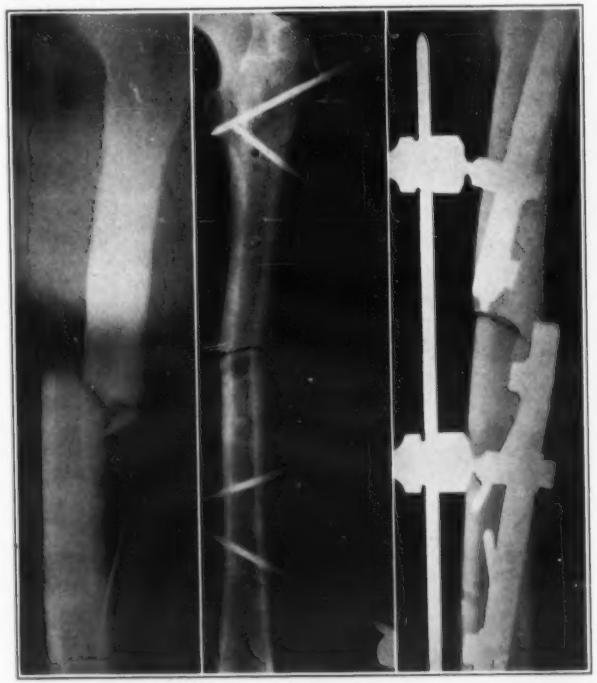

FIG. 8-A FIG. 8-B FIG. 8-C

FIG. 8-D FIG. 8-E FIG. 8-F

Case 8. L. C. C. was admitted with a simple fracture immobilized in a plaster cast. It had been treated with multiple wires, one of which still remained above the knee (Fig. 8-A). Dual pins were inserted and the fracture was reduced (Figs. 8-B and 8-C). Chronic infection necessitated removal of the pins after seven weeks. Surgery was necessary for chronic osteomyelitis (Fig. 8-D) two months later, and again nine months after the original injury. He was retired from the Service eighteen months after injury with the wound healed, but the femur was weak due to a large defect (Figs. 8-E and 8-F). Knee motion was limited to 16 degrees. One year later the femur fractured through this defect, but finally united.

This patient might have made a complete recovery if he had been treated by simple suspension traction or by delayed open operation. This is an example of the dangers attending the use of pins in the presence of wounds due to trauma or recent surgery.

FIG. 9-A

FIG. 9-B

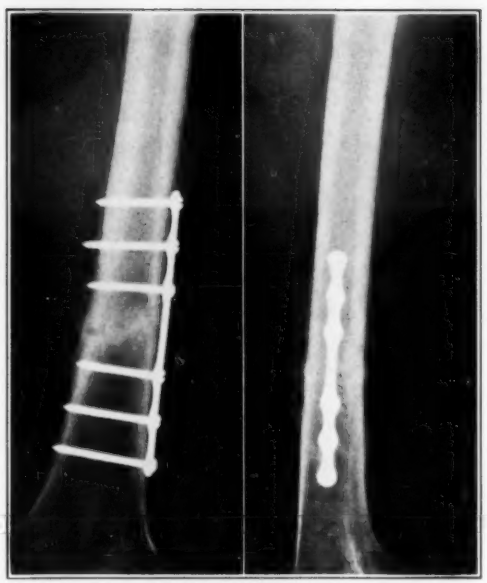

FIG. 9-C

Case 9. H. F. K. was admitted five weeks after a simple fracture had occurred. Reduction, which had been attempted by the insertion of a single half-pin through each fragment and immobilization in a plaster cast, had failed. The proximal pin had broken, leaving a fragment deep in the femur (Fig. 9-A). Skeletal traction was applied until the pin wounds healed (Fig. 9-B). The fracture was plated without difficulty, and the patient returned to full duty six months after the operation (Fig. 9-C). A month later the broken pin fragment was causing pain which was relieved by its removal.

This case illustrates failure where single half-pins have been used, the danger from defective pins, and the value of traction in preparing for operation.

FIG. 10-A

FIG. 10-B

Case 10. J. I. D. was admitted six months after injury, with a simple fracture that had been inadequately fixed with a plate and screws, both entirely too short. The plate was loose (Fig. 10-A). Bone graft was applied and fixed with four long screws (Fig. 10-B). The man returned to duty eight months after operation.

This case shows the need for a large plate and long screws, traversing both cortices, in open reduction of the femur.

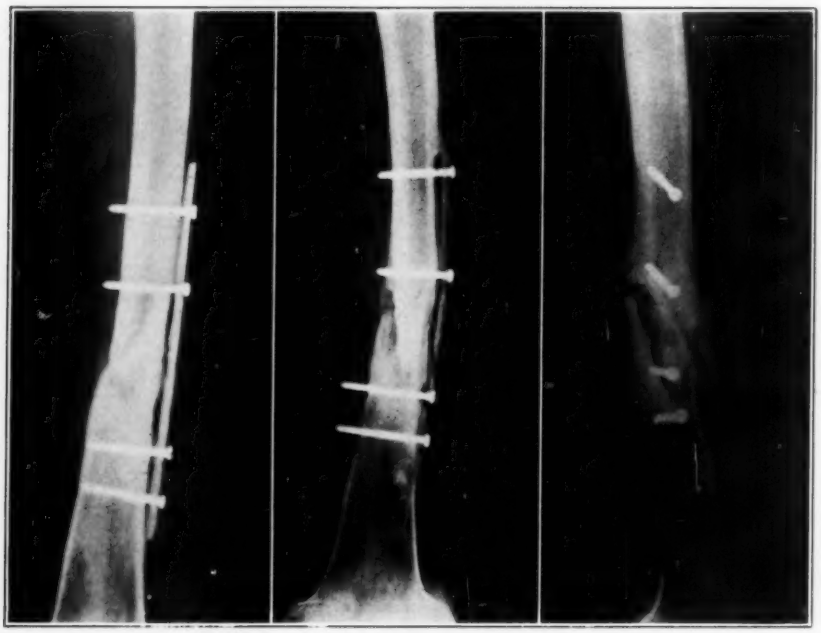

FIG. 11-A FIG. 11-B FIG. 11-C

Case 11. W. C. M. was admitted with non-union five months after simple fracture. Four months after his first operation (Fig. 11-A) the bone graft broke, necessitating a second graft (Fig. 11-B) which resulted in aseptic necrosis of the bone and persistent non-union (Fig. 11-C). The patient was re-admitted three and one-half years after injury, when a segment of bone was removed, and a third graft was applied. Progress was slow and the final result is unknown.

This case represents the only failure of a bone graft of the femur in a series of twenty-one cases. In this case the graft, unlike the others, consisted only of cortical bone, applied superficially and in poor contact with the host.

overriding. Suspension traction, if insufficient, does not correct deformity; if it is too powerful, it causes distraction; and in some cases it fails to approximate the fragments. Skeletal fixation with single pins or wires in each fragment is inadequate, and fixation with dual pins may fail or may cause infection. Open reduction with inadequate fixation by wire, bands, defective or small plates, or by short or insufficient screws invites failure. Very extensive surgery delays union and removal of large fragments results in non-union. The use of plates in old fractures is less successful than grafting. Bone grafts unite slowly if applied improperly and break if unprotected.

Many of these cases required grafting, and the author wishes to call attention to the type of graft used. The graft is massive, six inches long, and includes periosteum, cortex, and medulla. The host is prepared by removing sufficient cortex to make a flat surface and by making an opening into the medulla the full length of the graft. This is equivalent to an inlay graft, but no effort is made to channel the bone with the saw. Additional chips and medullary bone are used freely.

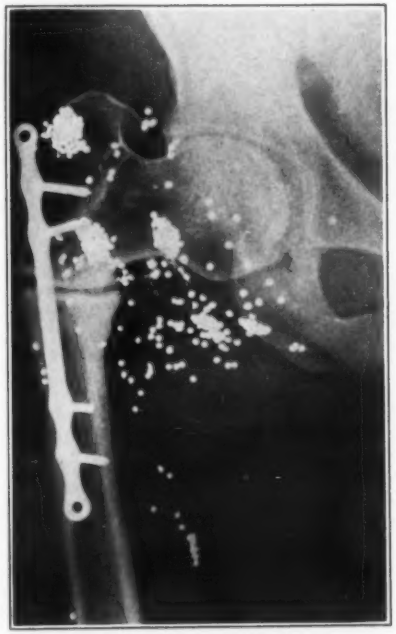

FIG. 12-A

FIG. 12-B

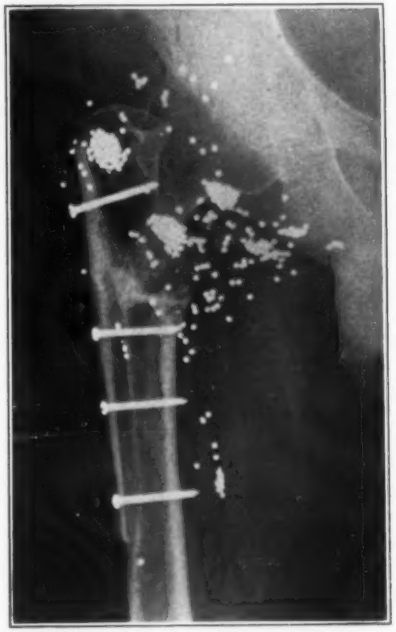

FIG. 12-C

Case 12. E. F. S. was admitted two years after an accidental shotgun wound at close range, with a non-union and three inches of shortening of the femur. The fracture had been treated by immobilization in a plaster cast, sequestrectomy, and plating (Fig. 12-A). The plate was removed after admission, and osteotomy performed at the site of the non-union (Fig. 12-B). Heavy skeletal traction gradually corrected the deformity. An old sinus became active, but healed to permit bone-grafting four months later. The graft was applied subcortically in the upper fragment, and the large defect was filled with chips (Fig. 12-C). Postoperative treatment consisted of a plaster cast with skeletal traction for three months, suspension traction for another three months, and finally a brace for four months. This treatment resulted in lengthening of one and one-half inches. The patient returned to limited duty in the Air Corps three and one-half years after injury, one year after the bone-grafting.

This case illustrates the importance of preventing deformity during prolonged treatment by using traction, the failure of plating in the presence of non-union, and the value of a two-stage operation in correcting deformity.

SUMMARY

This series of cases shows failure and success after various methods of treatment for femoral-shaft fractures. Failure results if any method is ill-chosen or misapplied. From the study of these cases, the author submits the following conclusions:

1. Immobilization of the femur in a plaster cast is a good procedure for transportation, but it does not prevent angulation and overriding, and its use for initial definitive treatment is not recommended. Prolonged immobilization in a plaster cast after the plating or bone graft delays the recovery of knee motion.

2. Suspension traction is the simplest and safest method of treatment and its trial is recommended for the average case. This method requires constant attention, the taking of frequent roentgenograms, and prolonged bed care. Distraction must be prevented. Fractures which are not quickly reduced by traction should have prompt open reduction.

3. Dual-pin reduction is suitable in certain cases, particularly for single fractures of the shaft of the femur. It is not recommended for old fractures, for fractures near the joints, or for those with a large, free, displaced fragment. In these cases, traction or operation is preferred. A single half-pin or a wire in each fragment is not sufficient fixation for the femur. In the experience of the author, this method is the least comfortable and the resulting knee motion does not meet expectations. Osteomyelitis does occur, and it is a serious complication that must be avoided.

4. Open reduction is an excellent method of treatment where facilities permit, and should be done as early as possible. However, open reduction with fixation alone does not assure union of the fracture. Success depends upon the use of material which is inert and of sufficient size and strength to be effective, and upon the preservation of an adequate blood supply.

5. Bone-grafting is necessary in cases of non-union, and is recommended when open reduction must be performed more than eight weeks after injury. A massive graft with all layers of bone in firm contact with the host should be firmly fixed with long metal screws. The addition of a plate is not always necessary, but it does ensure fixation, and permits earlier knee motion. The results of this operation have been gratifying in the reconstruction of the femur in these cases.

MALIGNANT SYNOVIOMA

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Very few well authenticated cases of malignant synovioma have been reported in the literature. The first definite case was that recorded as a synovial endothelioma by Lejars and Rubens-Duval in 1910. Smith in 1927 first introduced the term "synovioma" in a report of three cases. Since then, several others have been recorded. Knox in 1936 gave a comprehensive review of the literature. She accepted nineteen cases and added three of her own. The most recent and comprehensive paper is that by Berger in 1938. In a critical analysis of the literature he accepted only nineteen cases, and added five of his own. Hutchison and Kling (1940) reported one case, and drew attention to Coley and Pierson's series of fifteen cases which are not mentioned in Berger's paper. Coley and Pierson's cases, however, were not supported histologically. A recent paper on the subject is by De Santo, Tennant, and Rosahn (1941), who made a study of sixteen cases. Unfortunately, the authors were unable to obtain a copy of this paper because of its loss by enemy action. Haggart (1942) reported a synovioma of the knee joint, which had not recurred eight years after excision of the tumor. The majority of cases so far reported have been in the knee joint or its bursae. The synovioma here reported involved the right knee joint.

A. M., a sixteen-year-old weaver, was first seen in April 1941, complaining of a painful, swollen right knee of three months' duration. There was a history of trauma to the knee, but no relevant family illness. Examination revealed gross synovial thickening, and a doughy intra-articular effusion. There was also increased local temperature and one-half inch wasting of the thigh. Flexion alone was restricted by 30 degrees. The inguinal lymph glands, all other joints, the chest, the central nervous system, and the abdomen appeared normal.

Roentgenographic examination of the knee joints showed gross synovial thickening of the right knee, and slight osteoporosis of the lower end of the femur and the upper end of the tibia. There was no erosion of the articular surfaces, but some erosion of the inferior surface of the patella (Figs. 1-A and 1-B). The left knee was normal. Roentgenograms of the chest were normal. The Wassermann test was negative. The sedimentation rate by the Westergren method was twelve millimeters at one hour. Aspiration of the knee yielded a few cubic centimeters of clear mucinous fluid, light brown in color, and containing no tumor material. Culture and guinea-pig inoculation were negative for tuberculosis. Biopsy of a large inguinal lymph node showed several sections to be normal histologically.

Clinically the condition resembled an inflammatory lesion, and a tentative diagnosis of early synovial tuberculosis was made. The knee was immobilized, and expectant treatment was adopted. By July 1941, the swelling had increased, extending to four

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centimeters above the patella, and still resembling an inflammatory condition. Roentgenograms showed increased synovial enlargement, further osteoporosis, increased erosion of the patella, and commencing erosion of the tibial tubercle. Because of the progress of the disease under treatment, the knee joint was explored through a medial parapatellar incision. This revealed a diffuse grayish-white mass of tumor-like appearance, apparently involving the entire synovial membrane and capsule. The tumor was firm and homogeneous, with no evidence of necrosis. Adjacent muscles and fascia were infiltrated by it, but there was no evidence of invasion of bone or of the joint cavity. The joint contained an excess of translucent fluid, deep yellow in color and mucinous in appearance. The articular surfaces of the bones showed no erosion. Three specimens were taken from different parts of the tumor.

Microscopically the tumor was regarded as probably a malignant synovioma, and amputation was done one week later, August 25, 1941, through the upper half of the thigh, where the soft tissues and bone appeared healthy and uninvaded.

When examined in January 1942, the patient was well and the amputation stump was in good condition, but roentgenograms of the chest showed several round opaque shadows in the upper lobe of the right lung, extending toward the axilla. These were regarded as metastases. She was examined again in March 1942. Her general condition was still excellent, but roentgenograms of the chest confirmed the earlier diagnosis of secondary deposits in the right lung. These had increased in size, and the tracheobronchial glands were now enlarged. Roentgenographic examination of the skull and vertebral column failed to show any evidence of metastases. No preoperative or postoperative irradiation was given at any stage of treatment.

FIG. 1-A FIG. 1-B

Roentgenograms of right knee showing synovial thickening and erosion of the patella.

Histopathology

Through an unfortunate misunderstanding in the operating room, the amputated limb was destroyed before an examination could be made of it, so the material available

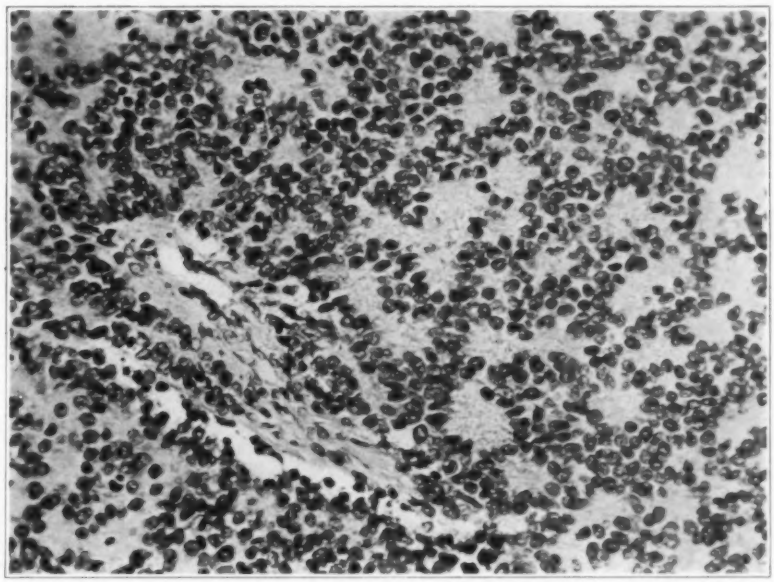

FIG. 2

Photomicrograph (× 250) showing rosettes in an undifferentiated part of the tumor.

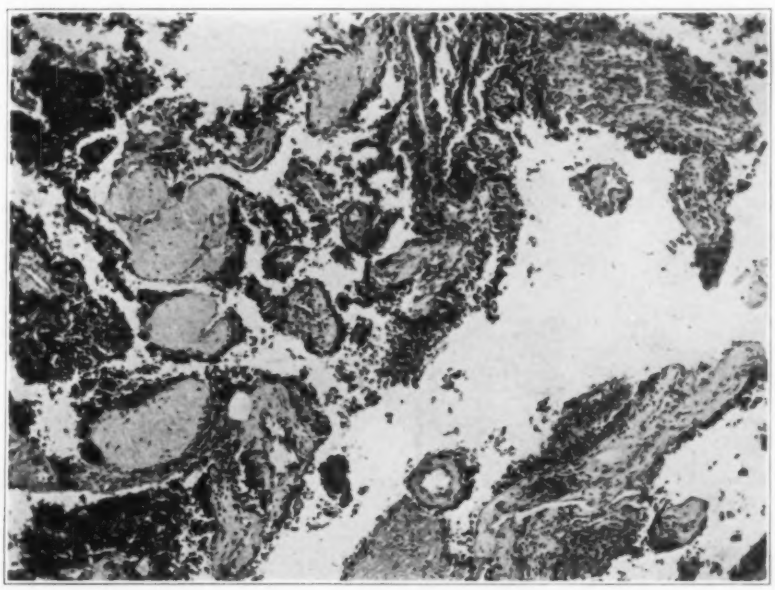

FIG. 3

Photomicrograph (× 60) showing papillary formation.

for histology consisted only of the three blocks of tissue removed at the operation in July 1941. Each was about one and five-tenths centimeters across. One of them included a small portion of the synovial lining of the knee joint. The consistency of the tumor was firm, and the cut surface grayish white.

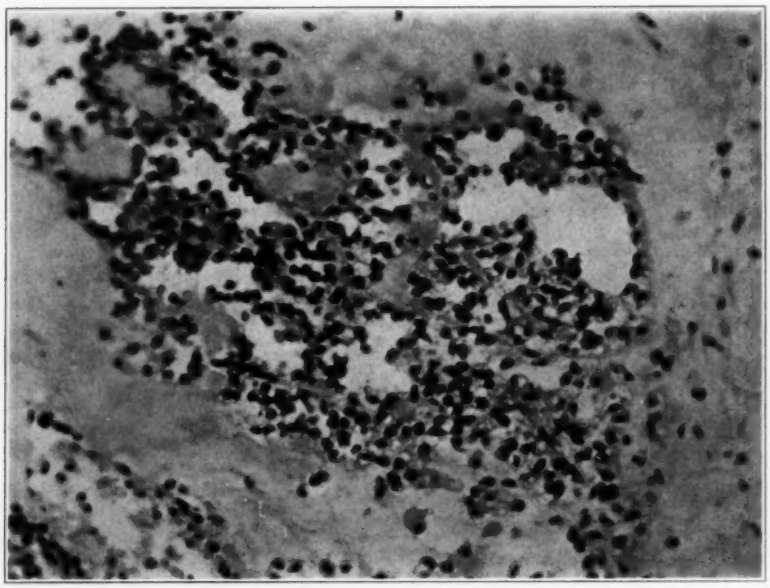

FIG. 4

Photomicrograph (× 250) showing the pseudoglandular spaces lined by tumor cells.

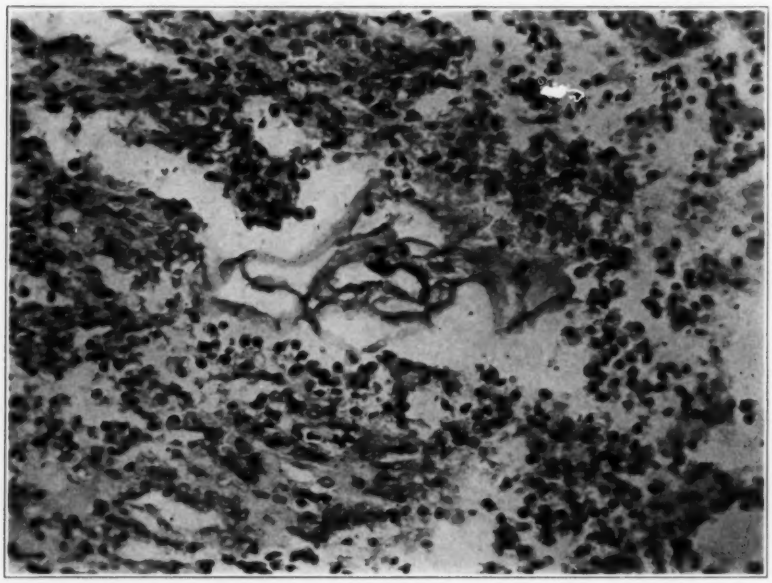

FIG. 5

Photomicrograph (× 250) showing strands of mucin. Mucicarmine stain was used.

Besides routine hematoxylin and eosin, the sections were stained by Van Gieson's method, Mayer's mucicarmine, Wilder's reticulin method, and Mallory's phosphotungstic-acid hematoxylin.

The sections showed a strikingly polymorphous tumor, partly solid and undifferentiated, and partly broken up by clefts and irregular spaces in which papilliform structures

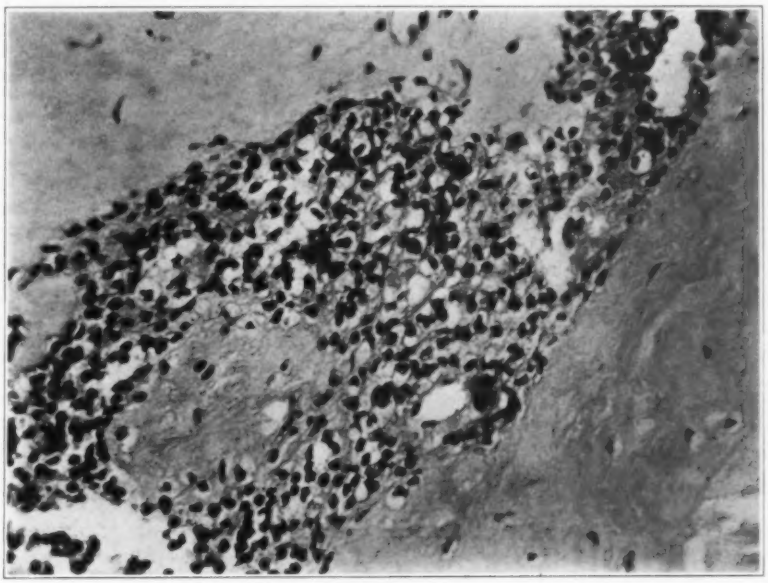

FIG. 6

Photomicrograph (× 320) showing the globular vacuolated cells representing lipophagic differentiation.

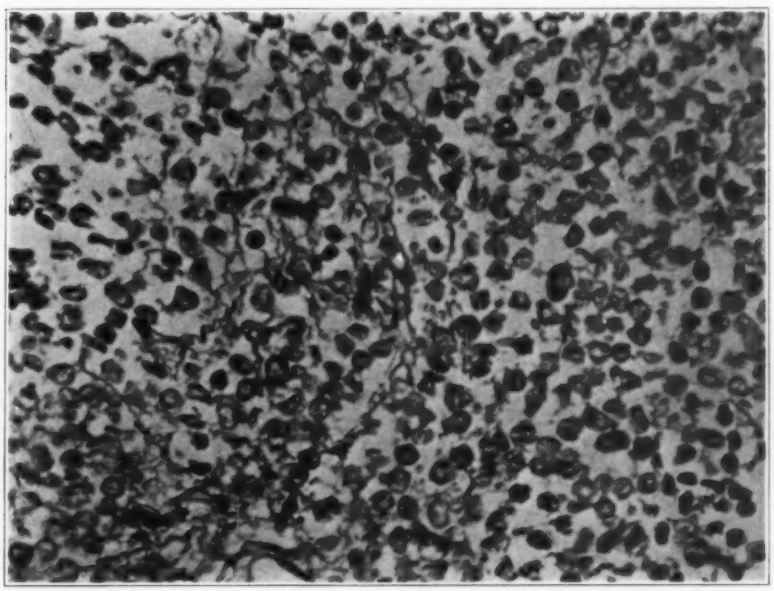

FIG. 7

Photomicrograph (× 500) showing the reticulin in an undifferentiated part of the tumor.

were present. The undifferentiated parts consisted of bulky masses of closely packed cells lying between broad bands of very dense fibrous tissue and invading neighboring islands of fat. Cell outlines were indistinguishable, the nuclei appearing to lie in a rough, somewhat vacuolated syncytium. The nuclei were oval or round, varied moderately in size, and had a scanty granular chromatin content. Irregular mitoses were frequently encountered. The nuclei were arranged either in diffuse sheets or so as to form rosettes and parallel columns (Fig. 2). The rosettes at first raised a strong suspicion of a neuro-

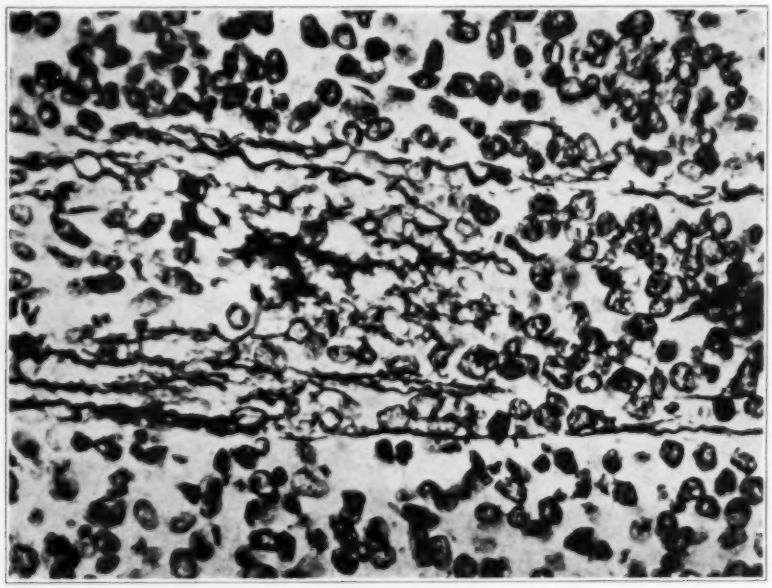

FIG. 8

Photomicrograph (× 500) showing straight reticulin fibrils.

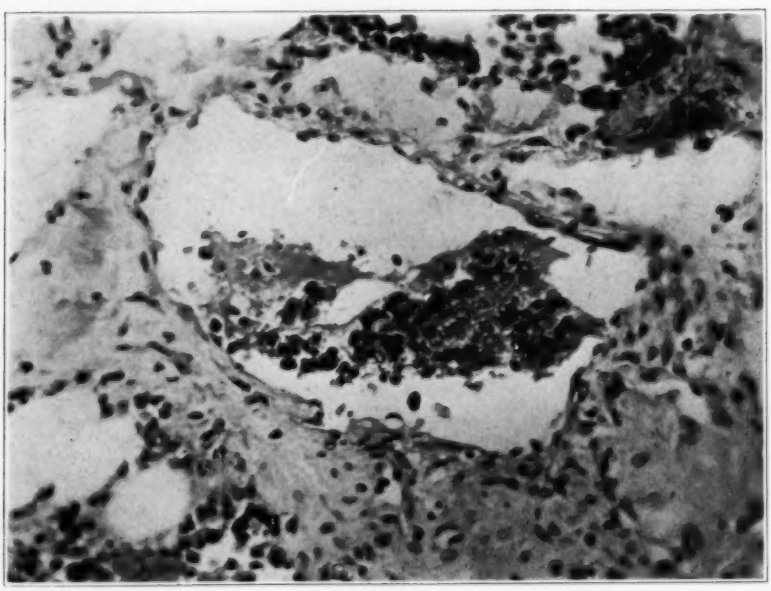

FIG. 9

Photomicrograph (× 250) showing tumor embolus in a vessel.

blastoma. The association, however, of a parallel arrangement of the nuclei, in long and short lines, suggested that the rosettes were really due to cross sections of cylinders of nuclei. No tangle of fibrils was demonstrable by Van Gieson's method in the center of the rosettes. With Wilder's reticulin method, some of the rosettes were seen to contain a few black dots, which probably represented cross sections of reticulin fibrils, for in the center of some of the parallel rows of nuclei a few long, straight reticulin fibrils were seen. Reticulin fibrils, arranged in sheets, were also present between the cells.

In two irregular spaces appearing between the cells, mucicarmine demonstrated red strands of what was presumably mucin (Fig. 5). Other larger oval spaces were seen full of eosinophilic secretion in which, however, no mucin was demonstrable. In the section that included normal synovial lining, many cells at the edges of the tumor masses showed a striking differentiation into larger globular forms with intensely vacuolated cytoplasm. These cells probably represented lipophagic histiocytic differentiation. In this section also, there were a number of tiny pseudoglandular spaces, lined by swollen cells of endothelial aspect. They were seen mainly in the midst of tumor cells, though occasionally they were in the fibrous stroma and were lined by a single layer of endothelioid cells. One or two loose dendritic cells were sometimes seen in these spaces.

In contrast to the solid parts of the tumor, there were many areas broken up by irregular spaces in which papilliform structures were present. The lining of these clefts and papillae consisted of loose masses of cells lying on dense fibrous tissue. They showed a florid and irregular growth, and varied from small flattened hyperchromatic types to large polyhedral forms of epithelioid aspect. Silver impregnation revealed a rich reticulin network in relation to these cells. Tumor emboli were seen in two small vessels (Fig. 9). Vascularity was moderate, the vessels being strikingly thick-walled and hyperplastic. Some small areas of necrosis were present. Hemorrhage was absent.

DISCUSSION

Vaubel has shown that cultures of synovial tissues produce a distinct cell type which he terms a synovioblast. According to Franceschini, Sabrazès and others, this cell appears to be of the nature of a reticulohistiocyte with peculiar properties of its own, among which are the formation of the pseudo-endothelial lining of joints, the production of synovial fluid with mucin, and also certain phagocytic functions. The cells are, as Kling points out, pluripotent. If this be a true conception, then the term synovioma, or better "synovialoma", should be applied only to those tumors which can be proved to arise from the cells characteristically found in the synovial membrane of joints, bursae, and tendon sheaths. Both benign and malignant growths are theoretically possible, and a classification on these lines has been attempted by Berger. Without going into a discussion on terminology, the name malignant synovioma appears to be the most satisfactory; alternative terms are synovial sarcoma and "synovialosarcoma".

The points in favor of this case being a malignant synovioma were first its site and topography, which suggested an origin from the synovial membrane of the knee joint, or an adjacent bursa. However, the exact diagnosis rested on the histology. The general polymorphous character of the tumor, the presence of reticulin fibrils, the evidence of histiocytic lipophagic differentiation, the mucin production (scanty), the presence of tiny pseudoglandular spaces, and the papillary structure, are all points mentioned as characteristic by Berger, Knox, Kling, King, and others.

The main alternative histological diagnosis was a secondary neuro-

blastoma. This was suggested by the presence of rosettes. They were, however, only pseudorosettes, and the other features of the tumor were not those of a neuroblastoma. Some areas of the tumor suggested a reticular-cell sarcoma, a feature noted by Berger in his first case, and due, no doubt, to the fact that these tumors are probably fundamentally reticulohistio-endotheliosarcomata.

Clinically it is often difficult to make the distinction, as was found in this patient, between chronic inflammation and neoplasm. Roentgenographic appearances are usually inconclusive, because the features common to both at an early stage are synovial thickening and osteoporosis; though our case showed some erosion of the patella even in the first roentgenogram, it was more marked in the second. The significance of the erosion present in the first roentgenogram was not appreciated. Lewis (1940) described certain characteristic roentgenographic appearances present in four cases, but his paper does not present conclusive histological diagnosis.

In view of the fact that histology revealed tumor emboli in blood vessels, and that metastases were demonstrable in the right lung six months after amputation, it is obvious that early diagnosis is all-important. This can be done only by biopsy. In this case, three months elapsed between the patient's first visit and the biopsy. The high malignancy of these tumors is confirmed by reports in the literature. Of the twenty-four cases accepted by Berger, only seventeen had been followed up efficiently. Of these, eleven had died with evidence of distant metastases, and four had local recurrence only. Of the fifteen cases reported by Coley and Pierson, only seven had been followed for four years or more after radical surgery. Three of these seven patients were either dead or dying with evidence of pulmonary metastases. There is, however, some doubt about the exact diagnosis in their cases. Hutchison and Kling's patient refused amputation, and died after seven years with pulmonary metastases.

Three possible lines of treatment have to be considered,—namely, local excision, radiotherapy, and amputation. Local excision has been followed by recurrence in practically all authenticated cases. In the four or five patients treated by irradiation, neither recurrences nor metastases were prevented. This suggests that the tumor is radioresistant. It is, therefore, generally considered, at present, that early amputation is the only effective treatment. If this is done early enough it should decrease the incidence of metastases and improve the prognosis.

SUMMARY

In view of the high malignancy of malignant synovioma, biopsy and early diagnosis are important. Early amputation is considered desirable in all cases. A case is reported and the literature is reviewed.

It is a pleasure to acknowledge the stimulating advice given by Prof. M. J. Stewart and Prof. H. M. Turnbull. The authors also wish to thank Mr. R. Broomhead, F.R.C.S., for permission to publish the report of this case, and Dr. A. S. Johnstone, for the radiological reports.

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RELATIONSHIP OF LEGG-PERTHES DISEASE TO THE FUNCTION OF THE THYROID GLAND *

BY A. BRUCE GILL, M.D., PHILADELPHIA, PENNSYLVANIA

In 1936, Cavanaugh, Shelton, and Sutherland reported studies in five cases of Legg-Perthes disease and stated that in all of them they found definite evidence of metabolic (thyroid) deficiency. This evidence consisted of the following observations:

1. The presence of colloid goiter in mothers, maternal aunts, and other members of the family.

2. Retarded development of the bones of the hand.

3. Other physical stigmata,—such as delayed and faulty dentition, hypogenitalism, cryptorchidism, enuresis, palpable thyroid gland, and dryness of the skin and the hair.

4. An early and consistent restoration of the head of the femur after thyroid therapy was instituted.

In addition to thyroid therapy, the authors prevented weight-bearing by means of a Bradford abduction-traction brace.

The author cannot but accept their observations classed under the first three divisions, but a careful study of their published cases with the accompanying illustrations leads him to doubt that the administration of thyroid materially shortened the period of regeneration or healing of the head.

It is known that the degenerative phase of the cycle lasts for approximately eighteen months and the regenerative phase for from twenty-four to thirty-six months, that adequate treatment by non-weight-bearing shortens the cycle, that absence of such treatment indefinitely prolongs it, and that the disease is often far advanced at the time of the onset of symptoms.

In their first case they state that the degenerative phase lasted for eighteen months from the onset of symptoms. At the end of this period the use of thyroid medication was begun, and progressive improvement was thereafter observed, with almost complete regeneration of the head noted at the end of fifteen months. However, an examination of the illustrations seems to show that complete regeneration did not occur until the end of twenty-seven months. The thyroid medication was begun at the time when evidence of beginning regeneration would ordinarily be expected. The regenerative phase of the cycle, therefore, required about the usual time. We cannot be certain of the exact time limits in the cases of these authors, because the illustrations of the roentgenograms are not sufficiently numerous, and because bone detail is not very good.

In their second case they report that the degenerative phase lasted

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 8, 1943.

for twenty-one months from the onset of symptoms. During the first twelve months the child had no treatment, and during the last nine months a brace was worn. At the end of this period of twenty-one months, thyroid extract was given. Regeneration of the head was noted for the succeeding thirty months. In this case also there is a conformity to the usual cycle.

In the third case they began treatment with a brace three weeks after the onset of symptoms. The roentgenographic illustrations indicate that the disease had been active for much longer than three weeks. The brace alone was used for four months with continuing degeneration of the head. Thyroid extract was then given and complete regeneration was noted at the end of twelve months. As far as the author can judge from the illustrations, regeneration had well progressed but was not complete at the end of sixteen months. In this case there seems to be a shortening of the regenerative phase following the use of thyroid extract.

In Case 4, the use of thyroid extract was begun one week after the onset of symptoms, and complete regeneration was reported thirty-five months later.

In Case 5, there was no treatment for fifteen months, at the end of which time there was complete destruction. The administration of thyroid extract and the use of a brace were then begun, and complete regeneration was reported at the end of twenty-two months. However, the roentgenogram taken twenty-nine months after the beginning of treatment seems to show that the head had not completely regenerated, and that it presented marked deformity. The end result should be classed as poor. This is probably due to the absence of non-weight-bearing treatment during the first fifteen months.

It is believed, therefore, that, from such analysis as can be made from these published reports, it is doubtful whether the use of thyroid medication shortened the degenerative or the regenerative phase of the cycle in these cases, with a possible exception of Case 3. However, the author would not presume to make a positive statement without an examination of the roentgenograms themselves.

It must be stated that the authors quoted do not claim that all cases of Legg-Perthes disease are due to thyroid deficiency. They presented their material with the hope that other investigators would study this disease to determine the individual metabolic status and refute or verify their findings.

It should be stated now that many pediatrists and endocrinologists recognize the difficulties that exist in making an accurate diagnosis of hypothyroidism, alone or combined with other endocrine deficiencies, except in those marked and long-continued cases which present the well-known symptoms of cretinism.

In adults, the lowered rate of metabolism, alterations in circulation, and changes in the skin, hair, subcutaneous fat, and muscles are evidences of thyroid deficiency. In children, defects in skeletal development which

are due to delayed growth are the most characteristic signs of this condition. Dwarfism, disproportion of upper and lower skeletal segments, infantile naso-orbital configuration, retardation of osseous development (for instance, in the bones of the hand), delay and irregularity in the calcification of epiphyses which produce a fragmented, or stippled, appearance in the roentgenogram, and delayed dentition are among the more common evidences of hypothyroidism. Mental sluggishness and lowered physical activity are usually seen to some degree in all cases of hypothyroidism.

When many or all of the above signs are present in a child, a diagnosis of hypothyroidism may accurately be established. However, it must be remembered that some of these defects in structural growth—such as dwarfism, osseous retardation, and defective dentition—may be found in children who do not have thyroid deficiency. Confirmation should be found in signs of physical and mental sluggishness, circulatory changes, and laboratory evidence of altered metabolism of the body.

The laboratory tests for hypothyroidism consist in the estimation of the basal metabolism, blood-serum cholesterol and phosphatase, creatine excretion, and in determination of the sensitivity of the patient to a standard dose of thyroxin as measured by its effect upon the serum cholesterol.

A little less than four years ago, in response to the stimulation of the paper written by Cavanaugh, Shelton, and Sutherland, a systematic study was begun of all cases of Legg-Perthes disease admitted to the University of Pennsylvania Hospital. The Departments of Endocrinology, Radiology, and Orthopaedic Surgery collaborated in these studies. Fourteen children were examined. During the past nine months six other children have been studied in the same manner at the duPont Institute (Nemours Foundation) for Crippled Children. These studies included family and medical histories, physical and mental development of the child, complete physical examination of all parts of the body, orthopaedic examinations, roentgenographic studies of skull and bone age of the hands and of the hips involved, and laboratory examinations.

The histories and physical examinations may be summarized by saying that in none of the twenty children were there evident any characteristics of hypothyroidism. All were members of the white race. None had palpable thyroid glands, cryptorchidism, subnormal physical or mental growth or activity, disorders of circulation, abnormality of skin or hair or subcutaneous tissue, or delayed dentition. (One child was moderately obese, and had a congenital inguinal hernia.)

ROENTGENOGRAPHIC STUDIES

The roentgenographic examinations of skulls were negative.

No epiphyseal dysgenesis was found.

Bone Age

Bone age was determined by routine roentgenographic examination

of the bones of the hand in all cases. The bone development and the chronological age corresponded in all but four cases. One child of six years had a bone age of four years, two of seven years had a bone age of four years, and one of four years had a bone age of two years. In these the basal metabolic rates were respectively +1, +2, +8, and +14. The blood cholesterols were normal, and there were no physical stigmata of hypothyroidism.

The readings of bone age were made in accordance with Todd's "Atlas of Skeletal Maturation (Part I—Hand)". If one reads carefully the introductory chapter in Todd's Atlas, he will appreciate the many difficulties in establishing standards of bone age. There is a natural variation in individuals, depending, for example, on their previous state of health and nutrition. He found that "children from undercircumstanced homes are often two standards (twelve months) below that which is recorded in our roentgenograms as equivalent to their age". There may be variation in the different epiphyses of the hand. In one case in which the chronological age was seven years, the carpal age according to the charts was two years and nine months, but at the same time the age of the radial epiphysis and of the phalangeal epiphyses was four years and nine months.

A retarded maturation of the bones of the hand should not be sufficient to warrant a diagnosis of hypothyroidism, unless it is confirmed by other evidences of this condition. To quote from Wilkins[3], "To attribute anatomic evidence of delayed development to thyroid deficiency, one should find confirmatory signs of diminished thyroid function, such as physical and mental sluggishness, circulatory changes, and metabolic or clinical abnormalities".

LABORATORY STUDIES

Basal Metabolism

Basal-metabolic rates in children were formerly considered to be unreliable because, in the first place, children readily became excited and fearful when undergoing such a test, and because, in the second place, it was thought that a standard metabolic rate in children had not been established. In recent years, however, many studies have been made on the basal metabolism of normal children, and Talbot's[4] standards are generally considered to be reliable. He observed that a basal-metabolic rate between the limits of +15 and −15 was present in 81.47 per cent. of seventy girls who were studied. Higher rates of +15 to +20 were observed in 5.38 per cent., +20 to +25 in 2.93 per cent., and +25 in 2.44 per cent. Lower rates of −15 to −20 were observed in 5.28 per cent., −20 to −25 in 1.91 per cent., and −25 in 0.59 per cent.

Talbot uses a specially devised cot-chamber apparatus for the basal-metabolic tests in children up to 130 centimeters in height and thirty-two kilograms in weight, and states: "When data have been obtained by means of the portable apparatus, the reliability of measurements

decreases as the patient's age decreases, with special rapidity under eight years". However, at the duPont Institute uniformly reproducible records have been obtained with the portable apparatus in children as young as three and one-half years, with the oxygen consumption falling within the limits set by Talbot in his cot-chamber series.

The conditions under which the basal-metabolic tests were made in the cases which are here reported were favorable. The children had been resident in the Hospital for a long period and were adjusted to hospital life. They were not alarmed or excited by the test, as it was merely a part of routine hospital attention. Repeated readings in the same child, as many as four or five in the duPont Institute, were remarkably uniform. The charts were smooth and regular. Under these conditions there seems to be no reason to believe that the tests are not as accurate as the tests in adults.

At the duPont Institute, control tests were made on children who did not have Legg-Perthes disease, but were normal except for some defect,—such as congenital club-foot. The control tests corresponded closely to those made in children with Legg-Perthes disease. All calculations were based on Talbot's standards for height and weight.

The basal-metabolic rates are given in Table I. It is observed that the tests made at the duPont Institute were more uniform than those made at the University Hospital. This was possibly due to more nearly ideal conditions at the duPont Institute, where the tests were made by persons who were in daily intimate contact with the children.

Most of the basal-metabolic rates should be considered as normal. The two with rates of −24 and −28 may be considered low. Unfortunately the tests were not repeated to determine whether the rate was consistently low. But in these cases the blood cholesterol was normal, the bone age was normal, and there were no physical evidences of hypothyroidism.

Blood calcium, phosphorus, protein, and sedimentation rate were within normal limits.

Glucose-tolerance tests were essentially negative, although a few of the children showed a moderate elevation of blood sugar two hours after the administration of the glucose.

Phosphatase. Talbot, Hoeffel, Shwachman, and Tuohy report that the serum phosphatase in seventy normal children ranged from 4.5 to 12 Bodansky units (according to Bodansky and Jaffe, the normal range is 5 to 14 units, average 7 units, in children from five to fourteen years of age). In twelve children with hypothyroidism, the phosphatase ranged between 1.3 and 4.3 units in eleven cases, while in the twelfth case it was 5.3 units. During the administration of thyroid extract the phosphatase reached normal levels and declined again on reduction or discontinuation of the medication. The authors conclude that the measurement of serum phosphatase provides a simple and reliable index of thyroid deficiency during infancy and childhood.

TABLE I

RESUMÉ OF CASES OF LEGG-PERTHES DISEASE AT THE UNIVERSITY OF PENNSYLVANIA AND THE DUPONT INSTITUTE

Case No.	Name	Sex	Age (*Years*)	Hip	Basal Metabolism	Bone Age	Blood Cholesterol	Calcium	Phosphorus	Phosphatase	Protein	Sedimentation Rate	Physical Defects
University of Pennsylvania													
1	R.T.	Male	10	Left	−14	Normal	200 [1]	10.9 [1]	3.8 [1]	4.4 [2]	6.1 [1]	9.0 [3]	Inguinal hernia
2	E.D.	Female	6	Right		Normal	227	10.9	3.95	7.22	6.4	5.0	None
3	B.F.	Male	7	Right	−4	Normal	298	11.4	3.53	3.93	5.97	5.5	None
4	A.G.	Female	4	Left	+3	Normal	207	11.1	3.98	5.26	6.13	6.0	None
5	L.S.	Male	5	Left	+4, −3	4	232	12.5	4.88	4.06		12.0	None
6	W.O'C.	Male	3½	Right	+17	Normal	265	10.8	3.98	2.72		15.0	None
7	H.C.	Male	10	Left	−8	Normal	178	10.9	3.2	3.2	7.0	8.0	None
8	I.Z.	Female	9	Right	−12	Normal	250	11.6	4.4	6.0	7.2	Moderate increase	None
9	P.F.	Male	8	Bilateral	+1, −8	Normal	240	10.3	4.2	7.4	6.9	17.5	None
10	P.McD.	Female	6	Left	−24, −13	Normal	248	10.2	3.5	5.4	6.6	18.0	None
11	R.R.	Male	7	Right		Normal	232	10.9	4.2	8.8	6.7	10.0	None
12	E.M.	Male			−10	Normal	266	10.7	5.1	9.8	6.8		None
13	T.H.	Male	7	Right	−28		177	9.4	4.4	14 (S) [4]	6.7	Slight increase	None
14	J.T.	Male	10	Right	−15	Normal	195	10.7	5.2	12 (S)	6.5	10.5	None
duPont Institute													
1	J.S.	Male	7	Left	H+2, W−3 (6) [5]	4	155	10.25	4.9	7.5	7.0	12.0	None
2	F.S.	Male	9	Right	H−5, W−2 (3)	Normal	172	11.84	4.5	4.4	6.9	7.0	None
3	S.F.	Male	7	Left	H+8, W+13 (3)	4	155	11.6	4.4	8.4	6.6	7.0	None
4	E.Y.	Male	5	Left	+1 (4)	Normal	158	10.6	4.7	8.1	7.0	8.0	None
5	J.S.	Male	3	Left	H−6, W+2 (5)	Normal	181	11.6	4.1	7.9	6.7	14.0	None
6	T.O'B.	Female	4	Bilateral	H+14, W+16 (4)	2	170 188	12.6	5.5	7.2	7.0	3.0	None

1. Blood cholesterol, calcium, phosphorus, and protein are shown in milligrams per 100 cubic centimeters of blood.
2. Phosphatase is shown in Bodansky units.
3. Sedimentation rates are shown in millimeters per hour.
4. (S) indicates Shim units.
5. H and W indicate height and weight adjusted to the standards of Talbot; and the figures in parentheses indicate the number of tests on which the average is based.

In these studies, the serum phosphatase was within normal limits in seventeen out of the twenty cases. It was below this limit in the patients in Cases 3, 5, 6, and 7, but in them the metabolic rate, the serum cholesterol, and the bone age were normal (Table I). Thus the phosphatase index in these three cases lacked the confirmation of other evidence of hypothyroidism.

Creatine Excretion. No measurements of creatine excretion were made. Wilkins[5] states, "there is a tendency for the creatine excretion to be low in the hypothyroid child, but it may be just as low in normal children. It is, therefore, impossible to differentiate the untreated hypothyroid child from the normal child on the basis of creatine excretion. Likewise, we have not found the creatine-tolerance test of diagnostic value".

Serum Cholesterol. The blood cholesterol was determined in all of the twenty cases of Legg-Perthes disease. They were all within normal limits. The determinations made at the two hospitals were slightly different, because two different methods of analysis were used, but the results were comparable, and in no instance was there an abnormal amount of cholesterol in the blood serum. Nine control cases were determined at the duPont Institute. They corresponded closely to the six cases of Legg-Perthes disease.

Sensitivity to a Standard Dose of Thyroxin Measured by the Effect upon the Serum Cholesterol. It is stated by Wilkins [8] that, in hypothyroid children, the administration of the standard dose of thyroxin causes a marked drop in the amount of blood cholesterol, amounting to as much as 120 to 230 milligrams per 100 cubic centimeters, and that the blood cholesterol does not return to previous levels for thirty to seventy days. He considers this test more important for diagnosis than the estimation of the basal-metabolic rate in untreated cases of hypothyroidism.

Three cases of Legg-Perthes disease (Cases 15, 16, and 19 in Table I) and two control cases were each given a dose of three milligrams of thyroxin hypodermically. In Case 19, the blood cholesterol before the administration of thyroxin was 177 milligrams per 100 cubic centimeters. Eight days after the injection it was 144 milligrams; at the end of fifteen days, 158 milligrams; and at the end of twenty-two days, 180 milligrams. The reactions in the other two cases conformed closely to those of Case 19. In the control cases the respective figures were 177, 137, 153, and 189; and 172, 153, 165, and 165. In these three cases of Legg-Perthes disease, and in the two control cases, the serum cholesterol was normal before the administration of thyroxin, the following drop was of minor degree, and the return to the preceding level occurred within twenty-two days. This sensitivity test indicates that hypothyroidism is not present in these cases.

The author may summarize his investigations in these twenty cases of Legg-Perthes disease by saying that no evidence of hypothyroidism was found in any of them.

Furthermore, one should not expect to prove that hypothyroidism is

an etiological factor in the causation of this disease. So far as thyroid deficiency has been found to be related to skeletal abnormalities, it has been observed to cause delay in bone growth. Epiphyses are late in appearing in the roentgenograms, and there may be irregularities in the conversion of cartilage into bone. Legg-Perthes disease consists of degenerative or destructive changes in an epiphysis which was *normal* before the onset of the disease. There is no evidence to prove that thyroid deficiency will cause destruction of a normal epiphysis and metaphysis.

It is believed by some writers that Legg-Perthes disease is identical in its processes and probably in its etiology with what is called osteochondritis in other parts of the skeleton. Do these other diseases involve an epiphysis and a metaphysis that have hitherto been normal, and do they manifest a similar cycle comprised of degenerative and regenerative phases, or are they instances of true epiphyseal dysgenesis? Köhler's disease of the tarsal scaphoid affects bone that does not develop from an epiphysis. The epiphysis of the tibial tubercle develops long before the usual age for the onset of Osgood-Schlatter disease. Osteochondritis of the spine appears at the age when the epiphyseal plates begin to appear in roentgenograms. The author is not sure that it can as yet be accepted that all types of osteochondritis are due to the same process and to one cause, such as hypothyroidism. This entire subject offers a fertile field for future investigations.

Schaefer and Purcell state their belief that juvenile osteochondritis is due to hypothyroidism and should be called "juvenile osteochondreal (chondro-epiphysitis) hypothyroidism". They report twenty-seven cases, including two cases of Legg-Perthes disease, two of slipped femoral epiphyses, ten of Osgood-Schlatter disease, six of apophysitis, five of Köhler's disease, and five of epiphysitis of the spine, in which there was evidence of hypothyroidism. They further state that all cases were given treatment by the administration of thyroid gland, that complete bone healing occurred, and that the course of the disease was shortened. They state that no immobilization or non-weight-bearing measures were necessary. They conclude, "Basic treatment, therefore, is adequate thyroid therapy. Orthopaedic procedures are secondary or adjunctive."

The author takes issue with them in their statements in regard to the two cases of Legg-Perthes disease. The only evidence they present of hypothyroidism is a basal-metabolic rate of −35 in the first case and of −28 in the second case. Both cases are said to be of the adiposogenital-pituitary type. The contention that they are hypothyroid in type is based largely on the effect of treatment by desiccated thyroid.

Case I. Symptoms of pain and limp had existed for seven weeks before the first examination, but the roentgenograms show that the disease was already far advanced. It had undoubtedly been present for many months before examination. This Case, as well as their Case II, illustrates the author's published statement that the disease at times is very far advanced before symptoms are apparent. Schaefer and Purcell report heal-

ing four years later. It would seem that the cycle was not shortened by thyroid therapy. Furthermore, the final roentgenographic examination, made five years after the first examination, shows that the head is very thin, broad, and flat, and that considerable coxa vara is present. This is a poor result, and it is undoubtedly due to the fact that the patient was ambulatory during the entire course of the disease.

CASE II. At the time of the first examination the patient had been complaining recently of pain in the left hip. The roentgenograms revealed a condition of Legg-Perthes disease in both hips. The right hip was far advanced in the regenerative phase. This was shown by the broad, thin, fairly well-consolidated head, and the thick, short neck. No mention is made that the child had ever had any symptoms referable to the right hip. Twenty-nine months later, the right hip had healed with considerable deformity. The administration of thyroid cannot be said to have hastened the healing. The left hip, at the time of the first examination, showed advanced degenerative changes. Twenty-nine months later, the left hip was extremely deformed, a very bad result indeed, and regeneration or healing was not completed. A broad area of decalcification was apparent in the metaphysis, and the head was not fully calcified. As far as one can judge from an illustration which does not show bone detail well, the author would think that at least another twelve months would be necessary to complete the healing. He does not believe that the time of the cycle has been shortened by thyroid therapy. And certainly the want of orthopaedic treatment has resulted in very marked deformity of the hip.

SUMMARY

1. A careful study of twenty cases of Legg-Perthes disease presents no evidence that this condition is due to hypothyroidism.

2. It is doubtful that all types of osteochondritis juvenilis are manifestations of the same pathological process and are due to one and the same cause.

3. Difficulties in diagnosis of mild or borderline cases of hypothyroidism should be recognized, and particularly so in relation to other endocrine deficiencies.

The author wishes to acknowledge his indebtedness to Edward Rose, M.D., and to Alfred Stengel, Jr., M.D., of the Department of Endocrinology, and to Eugene Pendergrass, M.D., and his assistants, of the Department of Radiology, at the University Hospital, and to Willie Smith, M.D., and Ernest B. Dunlap, M.D., of the duPont Institute.

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DISCUSSION

Dr. J. Albert Key, St. Louis, Missouri: I merely want to say that when that paper came out in 1941, I, like everybody, grabbed at the straw, and I started to treat cases of Legg-Perthes disease and some cases of Osgood-Schlatter disease with thyroid. I have not been able to notice that it made any difference in the course of the disease. As far as I have been able to go there has been no difference. I did have some low metabolism readings but these were not extremely low.

A TREATMENT OF CENTRAL FRACTURES OF THE ACETABULUM

A Case Report

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Anyone treating fractures may have occasion to treat a patient with a severe central fracture of the acetabulum. Almost invariably, too, the head and neck of the femur will have protruded into the true pelvis, pushing medially several large fragments of the inner table of the pelvis.

A large percentage of these fractures are sustained without visceral or genito-urinary involvement. The classical treatment usually consists in lateral and forward traction of the entire leg on the involved side, and, perhaps also, abduction and forward traction of the opposite leg to stabilize the pelvis so as to allow for more effective traction on the involved side. The turnbuckle-cast-leverage method of Jahss has also been employed in the management of this type of fracture. These methods, so far used in central fractures of the acetabulum, are directly dependent on the capsular ligament attachments for their reduction of the fragments. It is the capsule, attached to the femur at the intertrochanteric line and the rim of the acetabulum, which is really pulled. Those portions of the fracture sites unattached to the capsule, such as the inner table of the pelvis, are not influenced by femoral traction.

A case is presented of central fracture of the acetabulum which did not respond to the classical traction method, but which had a satisfactory result after an open reduction with internal fixation.

M. H., female, aged twenty-one, married, nullipara, had sustained an injury to her right pelvis when the auto in which she was riding was struck broadside by a truck on September 2, 1942. The patient lost consciousness, but regained it in the ambulance and arrived at the Hospital in semi-shock. Clinically a diagnosis of fracture of the pelvis was made. Roentgenograms at this time revealed a badly comminuted central fracture of the right acetabulum with marked involvement and displacement of the inner table of the pelvis (Fig. 1). The patient voided 100 cubic centimeters of clear amber-colored urine. She was treated for shock with blood plasma and fluids. Forward and lateral traction was then applied to the entire right leg. At the same time the foot and right side of the bed were raised about twelve inches so that the body might provide counter-traction. Approximately thirty pounds of forward traction (Russell) and eighteen pounds of lateral traction were applied to the right leg. The head of the femur was almost dislodged from the acetabular fossa laterally with only very slight restitution of the fragments, especially those of the inner table. Digital replacement of the fragments through the rectum was attempted; this was painful and unsuccessful (Fig. 2). If this unreduced position had been allowed to remain, it would have meant marked disability, manifested by pain and limitation of motion of the right hip. Also, if pregnancy ensued, the foetus would probably be unable to traverse through the true pelvis, and Cesarean

FIG. 1

FIG. 2

Fig. 1: September 3, 1942. Note the marked central displacement of the femoral head and acetabular fragments.
Fig. 2: September 7, 1942. The impingement of the fragments does not allow restitution by traction. Note the marked lateral and distal displacement of the femoral head. Traction has had very little influence on the fragments of the inner table.

FIG. 3
November 7, 1942

FIG. 4
December 18, 1942.

section would be necessary. An open operation was done seven days after the injury to improve the position of the fragments.

Operation

A Smith-Petersen incision was made over the anterior half of the iliac crest and forward on the anterior thigh for five inches. With a large periosteal elevator, the muscles attached to the crest of the ilium were detached subperiosteally from the lateral toward the medial side. The subperiosteal reflection was carried downward into the anterior iliac fossa, moving the iliacus and psoas medially, so that the viscera were retracted with the aid of Deaver retractors toward the opposite side of the pelvis. The exposure was more than adequate, as practically the entire fracture was visible. Large fragments of the inner table were gently replaced, and, when the inner table was tapped with a bone set, the entire area could be seen to fall into a completely reduced position. There was a tendency for two of the fragments to dislodge medially, so an 18–8 stainless-steel plate, which had previously been bent to conform with the natural curves of the inner table of the pelvis, was inserted. This plate spanned the fracture site obliquely from the anterior to the posterior sides, and from above downward. There was moderate oozing which was controlled with sponges. Two grams each of sulfanilamide and sulfathiazole were placed in the wound. The periosteum of the iliac fossa and the iliacus were reattached to the crest of the ilium, and were held in position with chromic No. 2 forty-day sutures which were passed through drill holes in the crest; this replaced the normal integrity of the oblique muscles, and the lateral and inferior abdominal wall. The patient was returned to her room where she was given 500 cubic centimeters of citrated blood, and the right leg was replaced in ten pounds of lateral and fifteen pounds of forward traction. Check roentgenograms, taken several days later, revealed satisfactory restitution of the fragments. Another roentgenogram, taken at the end of nine weeks of traction postoperatively, revealed satisfactory position (Fig. 3).

Five months after operation there is good union, with no evidence of aseptic necrosis of the head of the femur (Figs. 5-A and 5-B). Clinically the patient can completely flex,

FIG. 5-B

February 12, 1943. The femur can be rotated laterally.

FIG. 5-A

February 12, 1943. Position is still satisfactory. The acetabular fossa and intra-articular space have been restored. The femoral head is viable.

extend, abduct, and adduct the right hip. There is only slight limitation in internal rotation. The patient volunteers the information that, even with weight-bearing, there is no pain in the right hip region.

SUMMARY

The classical (traction) method employed in the treatment of severe central fractures of the acetabulum has frequently resulted in incomplete reduction, because it fails to affect the inner table of the pelvis. This lack of restitution of fragments has produced painful and limited arthritic hips.

A twenty-one-year-old woman, with a central fracture of the acetabulum and marked displacement of the fragments was treated by open reduction and internal fixation with a stainless-steel plate. The plate was placed subperiosteally in the iliac fossa.

When last seen, the patient had a hip which was freely movable without pain.

The author does not recommend that every central fracture of the acetabulum should be treated by open reduction or should be plated. The patient should be given a trial with traction, turnbuckle casts, or any other conservative method, and, if these fail within a week or ten days, an open reduction should be done in order to minimize the future disability, which invariably results from inadequate reduction.

SARCOMATA OF THE HAND SUBSEQUENT TO TRAUMA

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This report is published in order to contribute to a number of aspects of the problem of the relation of trauma to malignancy. The author's observations confirm the present opinion for the need of primary radical treatment; and to complete the study, he has included a brief review of the literature on synovial sarcomata to bring the subject up to date.

The author has found three good recent surveys of this general type of sarcoma: Coley, from the Memorial Hospital in New York; Berger, from Quebec; and most recently, De Santo, Tennant, and Rosahn from the Hospital for Special Surgery in New York. Coley and Berger reviewed about thirty previously reported cases, to which Coley added fifteen and Berger four. De Santo, Tennant, and Rosahn reported sixteen more in full detail, a total in all of about sixty-five, although there are undoubtedly a good many other cases which have not been noted in the journals.

The most common group of sarcomata are those developing from the capsules of joints, as is shown in Table I, a total of forty-three, compared to tumors of the bursae and tendon sheath, which number only seven and six, respectively.

TABLE I

LOCATION OF SYNOVIAL SARCOMATA

Knee	Elbow	Foot	Wrist	Finger	Bursa	Tendon
27	7	7	1	1	7	6

The characteristics of the reported cases of synovioma of the tendon sheath have been carefully analyzed in Table II.

The classification of these tumors is gradually becoming more settled and positive. It is known that in the typical kind which are here described, the uncontrolled cell proliferation originates from the synovial cells lining the tendon sheath, bursal sac, or joint capsule; and develops to a considerable degree, usually, before it penetrates the outer synovial cover. Mitotic figures are not numerous, nor are the proliferation and invasion of the lymphatics and blood vessels so active as to lead to early distant metastases. The parenchyma of these tumors consists of typical spindle-shaped cells, separated by varying amounts of interlacing bundles of collagenous tissue.

In some instances the histological pattern shows infolding papillomatous processes of cuboid or columnar cells associated with the spindle cells, leading some authorities to call them epitheliosarcomata or adenosarcomata. Occasionally there is a predominance of "foam cells" similar to

TABLE II

CHARACTERISTICS OF SYNOVIOMA OF THE TENDON SHEATH

Case No.	Surgeon	Sex	Age	Diagnosis	Location	Trauma	Treatment	Results
1	Berger	Female	75	Synovial sarcoma	Back of head	None	Local excision Secondary amputation	?
2	Knox	Male	25	Synovial sarcoma	Tendon sheath of forearm	?	Local excision Secondary amputation	Died in 10 years of lung metastasis
3	Black	Male	36	Mucoid sarcoma (non-malignant)	Hand	Crushing injury	Local excision	Good after 2 years
4	Coley	Male	22	Synovioma or endothelioma	Back of hand	Slight	Local excision	Died of pulmonary metastases
5	Coley	Male	27	Synovioma	Scar on palm of hand	Laceration	Biopsy, x-ray	Good after 2 years
6	De Santo, Tennant, Rosahn	Female	30	Atypical synovioma	Flexion tendon of the fourth finger	None	Local excision, 24 x-ray treatments Secondary amputation for recurrence	Good after 6 months

those found in xanthomata and ascribed to a metabolic disturbance. A benign tumor, described by Black as containing many polymorphous cells which secrete mucin, has likewise been placed in this group by some investigators.

From this it is apparent that the diagnosis of synovioma cannot always be made on histological grounds alone. Rather the surgeon, at the time of excision, must carefully trace the regional relationships of the tumor, so that the pathologist may have that additional information in correlating the gross-tissue findings with the histological picture, and may establish the diagnosis of synovioma.

In many of the cases so far reported, the diagnosis was not made until after local excision of the tumor. The growths were confused with fibromata, ganglia, lipomata, or cysts. Clinically, even on removal, they proved to be moderately firm solid masses whose nature could not be grossly identified. Some cases were accurately suspected, and a biopsy

needle was inserted, but this is a difficult diagnosis to make from needle puncture. If the surgeon must remove enough tissue for biopsy, he might better at the same time make a complete careful excision of the mass and surrounding tissues.

The relationship between trauma and malignancy is by no means clearly established. It is still possible to quote such negative opinions as that of Knox, who stated in 1934, "Finally, the writer believes that no valid evidence has been offered since 1929 to change the opinion expressed in a more extensive survey of this subject published at that time that as yet no causal relationship has been established between a single trauma to healthy tissues and the appearance of a malignant neoplasm".

On the positive side, the preponderance of opinion is headed by Ewing who said as early as 1926, "There is no doubt that under some circumstances a single trauma may produce a malignant tumor. I have seen several cases, and believe that there exists a considerable group of traumatic malignant tumors, in which, however, the traumatic origin has not been proven. We do not know how frequent they are. It is sometimes difficult to distinguish between trauma and chronic irritation."

Mock and Ellis reported nine neoplasms related to trauma and entitling their patients to compensation, notwithstanding the fact that the tumors may not have been caused directly by their injuries. It is their opinion that it is the surgeon's duty to decide whether or not a particular malignancy can be ascribed to trauma.

Coley is convinced that single trauma does cause malignancy, and adds, "It is only fair that the interests of the insurance companies should be safe-guarded as well as those of the patient; and in my opinion, compensation should be restricted to those cases which fulfill the conditions so admirably laid down by Segond".

These six postulates announced by Segond in 1907 are adequate criteria for establishing an opinion as to whether trauma is the etiological factor in any given case of malignancy. They are:

1. The authenticity of the trauma.
2. Sufficient importance or severity of the trauma.
3. Reasonable evidence of integrity of the part prior to the injury.
4. Correspondence of the tumor to the site of injury.
5. A date of appearance of the tumor not too remote from the time of the accident to be reasonably associated with it.
6. A diagnosis established by clinical and roentgenographic evidence, supported when possible by microscopic confirmation.

The conservative treatment of these sarcomata to date has been most discouraging. True it is that they grow slowly, recur at the original site, and metastasize late; but nearly all of them are radioresistant, and are almost impossible to eradicate completely by local excision. In one of the author's cases, a wide and careful local excision, that included removal of a metacarpal and finger, was performed; but recurrence took place at the site of the first small tumor. Roentgenotherapy is of doubtful value

at any stage. The author concurs in the general opinion that primary amputation is the treatment of choice, as soon as the diagnosis has been positively established. In those few cases where the tumor is small, circumscribed, and accessible, and permits of wide local excision, this can be tried and the recurrence awaited before the secondary amputation, which will probably follow in time. It is agreed that the early recurrence will be local and not in the lung where the terminal metastases usually occur.

The author's two cases reveal a number of common and interesting characteristics. The connection between tumor and trauma in each case seems reasonably clear according to the above postulates, and the Insurance Company accepted responsibility in both cases. The tissues were studied in three pathological laboratories, one of which was in a cancer hospital, and the descriptions and diagnoses were agreed upon. So far both patients are alive and well after four and two years. The detailed histories follow:

CASE 1. A white man, aged forty-two, was involved in an automobile accident in September 1935. His injuries consisted of a bad compound comminuted fracture of the right radius and ulna with avulsion of a great deal of skin and muscle of the forearm as well as the ulnar nerve and artery. The hand, which was the scene of the later tumor development, was severely battered and swollen, and received several lacerations over the dorsum, but no fractures. The general avulsion proceeded from the carpal bones upward. Careful cleansing and débridement were performed, and traction was applied by means of Kirschner wires through the olecranon above and the metacarpals below. By dint of great care enough circulation was maintained to preserve the hand, and, at the end of eight weeks, the skin was completely covered over by early grafts. However, non-union of the fractures developed, and secondary operations were necessary before final union took place. The eventual result was a skeletonized hand which had little function because of the loss of so many nerves and tendons. After nineteen months, his case was settled at an informal hearing of the Compensation Court who awarded him 85 per cent. disability loss of the right hand and arm.

In 1937 there was a short interlude of cellulitis of the forearm. In 1938, likewise, he suffered a brief flare-up of infection which had as its origin a low-grade osteomyelitis at the site of the fracture. Between times he was employed as a watchman.

In March 1939, four years after his original injury he called attention to a small nodule on the back of his crippled hand. In a month it had grown in size, and its removal was decided upon. A few days later, under general anaesthesia, an irregular, partially encapsulated, wine-colored tumor was carefully and widely excised. It involved the fibrous and fascial tissues around the fifth metacarpal bone and was firmly attached to it near its head. The distal end of an avulsed extensor tendon lay alongside.

Histological examination showed a complex picture composed of a great number of oat-shaped cells which in many areas had two mitoses per high-power field, and had centrally placed ovate nuclei and abundant cytoplasm which was markedly vacuolated. These cells were accompanied by a good many capillaries and slender strands of collagen which coursed in various directions. In other parts the tumor cells were much more widely separated, and became spindle shaped with a large amount of collagen between the individual cells. At wide intervals there were isolated small multinucleated giant cells. There were several areas of extensive hemorrhage. The tumor seemed to be enclosed by a single capsule which had not been infiltrated.

Because of the general uselessness of the hand, it was not difficult to decide upon amputation, which was performed in May 1939. To date, after nearly four years, there has been no evidence of metastasis.

CASE 2. A white male, aged twenty, struck the back of his left hand against an iron door, and was referred by his employer to the compensation physician who examined his hand, and said that he might have a fracture. He re-examined him two or three times, while the pain diminished and the swelling went down. The boy states that the swelling never completely disappeared. A small lump remained, and after a time it slowly grew larger. Finally it reached such size as to annoy him by its appearance, but it caused no other symptoms. About two years after the original accident, he again complained to his employer about it. The Insurance Company was consulted, and the case was referred to the author for removal of the mass which was thought to be a ganglion. The Insurance Company maintained that the case was outlawed by time, but accepted responsibility at the request of the employer.

At the first operation, in November 1939, the tumor was excised under local anaesthesia in the author's office. It was subcutaneous, somewhat movable, and located over the center of the second metacarpal shaft. Most of it could be shelled out, but the under surface was attached to the fascial tissues covering the bones and muscles. It was not attached to any tendon and was not connected with the wrist joint. The tumor was a firm white mass about an inch long by three-quarters of an inch wide.

The report of the histological examination was as follows: "composed of relatively small spindle-shaped cells which in some areas are closely packed and arranged in interlacing bundles, and in other areas more widely spaced and without definite arrangement. In the more compact areas there is a small amount of intercellular material which is probably collagen or reticulin. In the looser areas, the cells tend to be stellate rather than spindle shaped, and have no definite arrangement. The nuclei are hyperchromatic, elongated, and show mitoses on an average of two in every high-power field. In some areas mitotic activity is much greater, and as many as eight can be found in a single field. The tumor is poorly vascularized, but, where blood vessels are found, they seem to have a definite endothelial lining. Along one margin is a thin membrane which is probably capsule. This appears to be invaded by tumor cells".

After numerous consultations, and partly because of the boy's own preference, a wide excision was performed on January 3, 1940. All of the tissue in the area was carefully dissected, the second metacarpal bone was removed, and along with it the first finger in order to give a better functional result. The wound healed quickly, and he returned to work in five weeks with a perfectly useful hand.

However, a recurrence was apparent by June 1940 at the original site, and thereupon amputation was performed at the mid-forearm. The recurrent tumor showed more mitotic nuclei and other evidence of increasing malignancy. It was quite positively identified as a sarcoma of synovial origin.

To date there has been no evidence of metastasis.

CONCLUSIONS

1. Tendon-sheath synovial sarcomata are rare.
2. This diagnosis should be suspected in any soft tissue of the extremities, especially around the joints, tendons, or bursae. Usually, however, it is made by the pathologist after local excision.
3. A single trauma was the reasonable etiological factor in both of the author's cases which were accepted as compensable by the Insurance Company without recourse to judicial action.
4. Trauma may be more of a factor in sarcomata than has previously been suspected.
5. Primary amputation is still the treatment of choice.

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TRAUMATIC SEPARATION OF THE LOWER FEMORAL EPIPHYSIS *

BY SIDNEY SIDEMAN, M.D., CHICAGO, ILLINOIS

This injury has been called the wagon or cart-wheel fracture. In horse-and-buggy days, it was frequently sustained when a leg was caught between the spokes of a moving wheel.

The author wishes to report two cases of this type of fracture, which have come to his attention.

CASE 1. This patient, a boy, fourteen years of age and weighing 240 pounds, fractured his left femur while playing football, when he was struck by another player. Roentgenograms taken after the injury (in October 1941) showed the usual type of displacement (anterior) of the femoral epiphysis, and a lateral metaphyseal fracture. The

FIG. 1-A

FIG. 1-B

Fig. 1-A: Case 1. Roentgenogram showing usual type of displacement (anterior) of the femoral epiphysis.
Fig. 1-B: Result five months after reduction.

fracture force, acting upon the anterolateral aspect of the femur, had been resisted by the standing position of the patient. A pivot rotation had completed the fracture. The epiphyseal plate and the lateral metaphyseal fragment were carried with the epiphysis, resulting in a hyperextension fracture of the knee with an anterolateral displacement of the epiphysis.

Closed reduction was performed under general anaesthesia, with the patient on a fracture table. Strong, downward traction was used on the extended knee in the line of the leg, combined with an anterior thrust of the femur and a posterior thrust of the

* Presented before the Chicago Orthopaedic Society, March 1942.

FIG. 2-A

FIG. 2-B

Case 2. Roentgenograms showing unusual type of displacement (posterior) of the femoral epiphysis.

FIG. 2-C

FIG. 2-D

Result five months after injury.

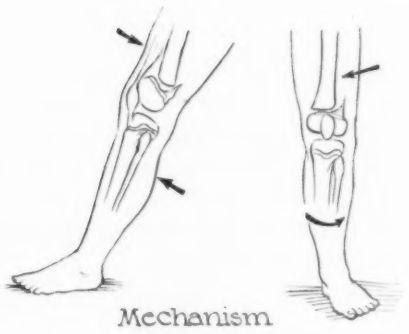

FIG. 3-A

FIG. 3-B

Diagrams showing mechanism, manipulation, and maintenance in Case 1.

tibia. Force was then exerted laterally on the femur and medially on the tibia. Internal rotation of the tibia completed the reduction. The displacement was corrected in one plane at a time. The knee was then flexed as much as the swelling would permit, the femur being forced anterolaterally and the tibia posteromedially. Taut anterior structures acted as a sling to prevent further displacement. An assistant applied a single hip spica, which was replaced six weeks later by a weight-bearing cast from groin to ankle, to be worn for another six weeks. When the second cast was removed, the patient was instructed in mobilization exercises.

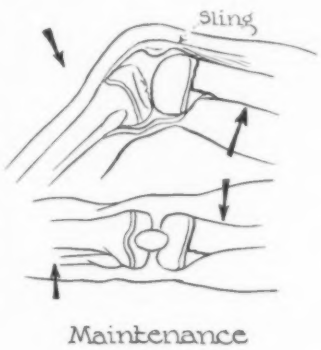

FIG. 3-C

After four months he had a complete range of knee-joint motion, and was carrying out normal activities without the aid of apparatus. He had received no physical therapy.

CASE 2. This patient, a fourteen-year-old boy, weighing 120 pounds, fractured his right femur while riding a horse. As the horse galloped through the open doorway of a barn, the boy's leg was caught on the side of the doorway and fractured. An unusual type of displacement (posterior), and a lateral metaphyseal fracture were revealed by roentgenograms taken after the accident (August 1941). The fracture force, acting through the foot and leg upon the flexed knee, caught on the side of the doorway, had been resisted by posterolateral pressure of the femur against the saddle. External rotation had completed the fracture.

As with the previous patient, general anaesthesia was used during the closed reduction of the fracture. Strong, downward traction on the flexed knee, in the line of the leg, was combined with a posterior thrust of the femur and an anterior thrust of the tibia. Force was exerted laterally upon the femur and medially upon the tibia. Internal rotation of the tibia completed the reduction. Again correction was made in one plane at a time. Reduction was maintained by hyperextending the knee, the fragments being kept in position by forcing the femur posterolaterally and the tibia anteromedially. Taut posterior structures acted as a sling to prevent further displacement. As with the previous patient, a single hip spica was replaced after six weeks by a groin-to-ankle weight-bearing cast which was worn another six weeks.

At the end of four months, the boy had a complete range of knee-joint motion, and he had discarded all apparatus. However, he had had six "psychophysical" therapeutic sessions.

DISCUSSION

It should be noted particularly that the femur fractured in extension was reduced in extension and maintained in flexion, while the femur fractured in flexion was reduced in flexion and maintained in extension. In neither patient did circulatory or neurological symptoms develop, because the important popliteal structures were not traumatized. There was, in both patients, extra-articular swelling due to hemorrhage. Closed reduction was the procedure used in both fractures.

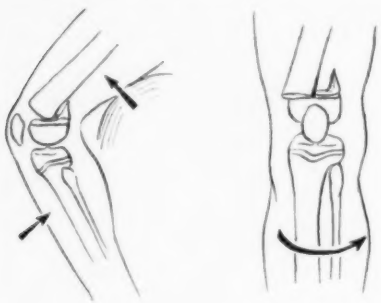

FIG. 4-A

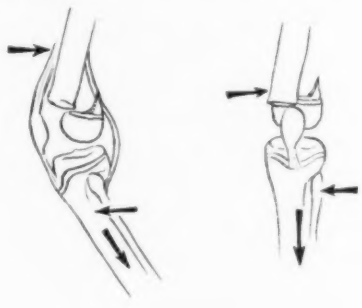

FIG. 4-B

Diagrams showing mechanism, manipulation, and maintenance in Case 2.

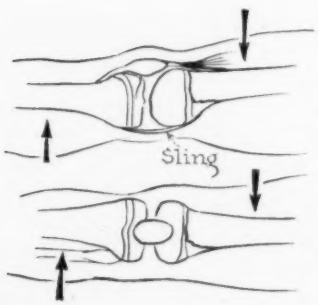

FIG. 4-C

Open reduction is rarely necessary, if the limb is carefully manipulated and fixed. Pins and nails inserted through the fracture may cause an irregular or premature arrest of growth and should be avoided. Growth arrest does not usually occur because the epiphyseal plate remains intact and attached to the epiphysis. However, it can occur. Incomplete reduction may lead to a cessation of growth. Either or both sides of the epiphysis may be affected, resulting in shortening or deformity. If the posterior growth ceases while the anterior continues, a flexion deformity will develop. From growth irregularities, extension, flexion, and lateral deformities of the knee may be expected.

The patient and those responsible for him should be warned that, even with perfect anatomical reduction, growth disturbance may produce an unfavorable result.

OSTEOCHONDRITIS OF THE EPIPHYSIS OF THE TERMINAL PHALANX OF A FINGER

Report of a Case

BY O. SHERWIN STAPLES, M.D., BOSTON, MASSACHUSETTS

From The New England Peabody Home for Crippled Children, Newton, Massachusetts

Since Osgood, in 1903, described osteochondritis involving the epiphysis of the tibial tubercle, many reports have been made in the literature, describing similar processes in the various growth centers. The nomenclature of the many varieties and locations of this type of disturbance is confusing, due largely to the fact that the similarity of the process in different locations was at first not recognized. As a result, in each of the growth centers commonly involved, the process was considered as a separate disease entity, often associated in nomenclature with the man or men who first described the condition,—as in Lægg-Calvé-Perthes disease.

More recently, the fundamental similarity of these disturbances of the growth centers has been pointed out [4, 6], and the various types of this disease have been grouped together under the term "Osteochondritis of the Growth Centers".

The literature dealing with this subject has been exhaustively reviewed in the article by Harbin and Zollinger, which reveals that almost every growth center in the body can be involved by this disturbance. The etiology of this type of osteochondritis has not been fully discovered. It is possible that insufficiency of the blood supply to the involved epiphysis plays a rôle, because of a demand during rapid growth for more than the possible supply. [6] A history of trauma can be elicited in many cases, but is not constantly present. An endocrine imbalance is a possibility.

Osteochondritis of the epiphyses of fingers and toes has been reported by several authors. [1, 2, 3, 7] The changes reported consisted of fragmentation of the epiphyses of metacarpals, metatarsals, and proximal phalanges, with permanent deformity as a result. In a review of the literature, only one case similar to that reported here was found. A case of osteochondritis or aseptic necrosis of the epiphysis of the terminal phalanx of a finger, following definite trauma, was mentioned by Watson-Jones. The reproduced roentgenogram is identical with the illustrations of the case here reported. The end result was not given.

The following case is of interest because it represents an unusual type of osteochondritis of a growth center, and includes a follow-up study. This patient also had quiescent tuberculosis of the spine, but at no time was there any evidence clinically or by roentgenographic examination that the process was due to tuberculosis.

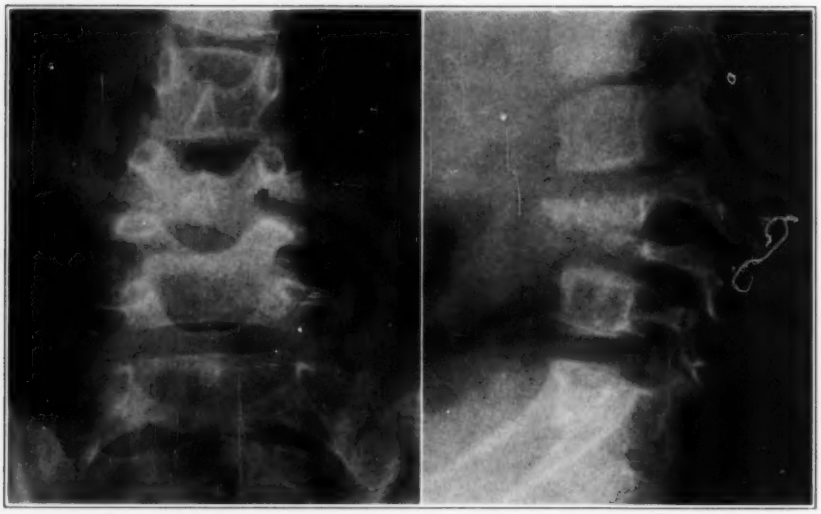

FIG. 1-A FIG. 1-B

C. M. May 1941. Anteroposterior and lateral views of the lumbar spine.

CASE REPORT

C. M., a girl, aged two years and one month, was admitted on October 19, 1938, to The New England Peabody Home for Crippled Children with the diagnosis of tuberculosis of the spine. Five months previously, the mother had noted prominence of the lumbar spine, followed in three months by occasional pain.

The physical examination upon admission was negative, except for prominent mid-lumbar kyphosis, a cold abscess palpable in the left flank, and moderate psoas spasm on the left. Roentgenograms of the spine showed a destructive process characteristic of tuberculosis, involving the third, fourth, and fifth lumbar vertebral bodies. Roentgenograms of the chest were normal. The tuberculin test was positive in a 1 to 10,000 dilution.

FIG. 2-A FIG. 2-B

May 1941. Anteroposterior views of both hands.

FIG. 3-A
May 1941. Left index finger.

FIG. 3-B
May 1941. Right index finger.

The patient was treated by bed rest in a bivalved plaster jacket until February 1941, two and one-third years after admission. During the first six months that the patient was in the hospital there was a slight increase in the destructive process, as shown by roentgenographic examination, but subsequently the destructive phase stopped, and recalcification and regeneration of bone began. At the end of the first year of treatment, the patient's general condition was good.

Fifteen months after entry, the cold abscess present in the girl's left flank ruptured spontaneously. The resulting sinus healed after five months. There was no evidence of secondary infection at any time. Guinea-pig inoculation with material from the abscess was negative, but, because of the clinical course and other findings, the diagnosis of tuberculosis was maintained.

In February 1941, the patient was allowed to be ambulatory in a back brace. She was given gradually increasing periods of activity each day with no resulting ill effects.

In May 1941, two and one-half years after entry into the hospital, the patient, then four years and eight months old, complained of pain in her right index finger. As far as could be determined, there had been no previous finger symptoms or trauma of any sort. Examination revealed redness, tenderness, and swelling, confined to the region of the distal interphalangeal joint, with no evident joint effusion. The motions of the finger were normal.

Roentgenograms of the hand showed that the epiphysis of the distal phalanx of the right index finger was smaller and denser than normal (Fig. 2-B). Roentgenographic study of the spine showed no evident activity of the tuberculous process. The disease appeared quiescent, with questionable spontaneous fusion of two of the vertebral bodies involved (Figs. 1-A and 1-B).

A splint was applied which held the affected finger in extension. The splint was removed after two weeks, when symptoms had disappeared and the hand had apparently become completely normal. No further treatment was given. There were no further symptoms or signs in the finger during the following nineteen months.

During this period the patient's general condition remained excellent.

In January 1942, a spine fusion was performed, which

FIG. 4
July 1941.

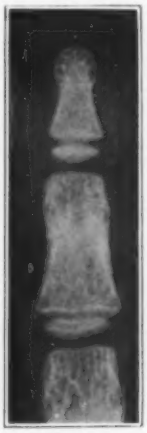

FIG. 5
September 1941.

FIG. 6
October 1941.
X-rays of right index finger, showing improvement.

FIG. 7-A

December 1942. Left index finger.

FIG. 7-B

December 1942. Right index finger.

had been postponed previously because of the respiratory infection.

Four months after operation, the girl was again allowed to be ambulatory in a back brace, and her further hospital course was uneventful.

Roentgenographic studies of the affected finger were repeated at intervals during the nineteen months following the onset of finger symptoms. Gradual improvement was noted in repeated roentgenograms, and, after five months, the previously abnormal epiphysis was entirely normal in appearance. Final roentgenograms taken in December 1942 show no difference in the two hands (Figs. 7-A and 7-B).

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MARCH FRACTURE OF THE TIBIA

Report of a Case

BY CAPTAIN EMANUEL BLUMENFELD

Medical Corps, Army of the United States

From the Station Hospital, Fort Dix, New Jersey

It appears that, although numerous instances of march fracture in the metatarsal bones have been described, only a scant number have been observed in the long bones. Recently a report [1] of a march fracture of the femur with complete recovery was described. This report also indicated that heretofore only two cases of march fracture in the femur and two in the tibia had been reported. The following is a description of a case occurring in the tibia.

L. P., a twenty-three-year-old white soldier with nine months of service, had three admissions to the Station Hospital, Fort Dix, New Jersey. On his first admission, May 13, 1942, his chief complaint was pain in the right leg four inches above the internal malleolus at the site of a slight swelling. He was a well-developed male, not acutely ill, who limped slightly because of pain in his right leg. The only past illness which appeared to be related to this admission was intermittent episodes of athlete's foot for the preceding eight years. In his nine months of Army Service, he had been a cook in his organization, standing about thirteen hours a day. He did not participate in athletics, and did little drilling and no hiking. There had been no increase in the amount of standing or walking prior to his present illness. It appeared that on the afternoon of May 9, 1942, he had noticed a spontaneous onset of pain and swelling in the lower part of his right leg on the medial aspect; it was particularly painful on walking, but not on resting.

Physical examination revealed a six-foot, white soldier weighing 170 pounds, whose temperature, pulse, and respiration were normal, and remained so throughout hospitalization.

There were some superficial skin lesions between the toes, and moderate swelling and tenderness about four inches above the right internal malleolus. The tentative diagnosis on admission was cellulitis of the right lower leg secondary to epidermophytosis. Laboratory studies were completely negative. The roentgenographic report on May 12, 1942, was as follows:

"There is a slight thickening of the periosteum noted on the medial surface, distal end of the shaft of the right tibia about seven centimeters from the distal end. There is an incomplete fissure noted at this point. There is no evidence of any destructive lesion of the right tibia."

The skin consultant described a subsiding and mild trichophytosis corporis of the feet. Following bed rest and magnesium sulfate dressings, the swelling subsided in ten days, and the patient was discharged to duty on May 20, 1942.

The patient was readmitted June 12 with a similar complaint of swelling of the right leg of three days' duration. He stated that three weeks following his previous discharge, or three days prior to his present admission, the swelling of his right lower leg had developed again without a history of trauma. He noted that the swelling subsided on rest. Local examination at this time revealed slight induration on the medial border of the lower third of the right leg, but no swelling or redness.

The diagnosis at this time was periostitis chronic, non-suppurative, of the medial surface of the lower third of the right leg, cause undetermined. The x-ray report reads:

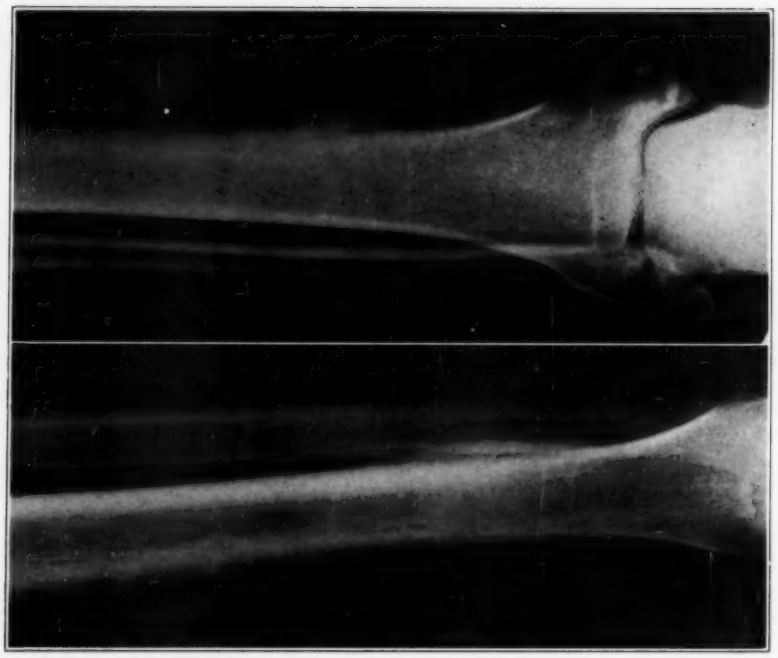

FIG. 2

July 7, 1942, fifty-nine days after onset of symptoms, roentgenograms reveal diminution in the width of the fracture line, and an increase in the callus formation.

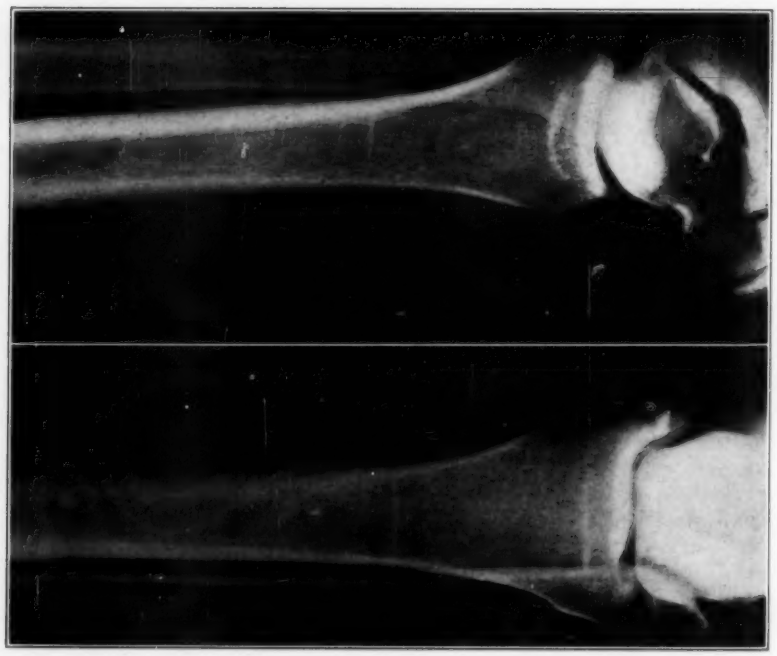

FIG. 1

June 12, 1942, right leg, showing definite fracture line and beginning of callus formation.

"Examination at this time shows a moderate increase in the periosteal thickening which appears like bony callus formation. The previously reported fissure is more clearly demonstrated at this time. A diagnosis of incomplete fissure fracture must be made." (See Figure 1.)

The patient's complaints rapidly subsided with bed rest and elevation of the extremity. His temperature, pulse, and respiration rates were normal throughout hospitalization, and laboratory data were again normal. He was discharged June 18, 1942.

The third admission was on July 5, 1942. At this time he presented a recurrence of the swelling in the lower leg which he felt was increasing in size. He had noted this three days prior to admission. Local examination revealed mild swelling (six centimeters by six centimeters) over the anteromedial aspect of the right lower tibia, essentially bony and apparently representing periosteal thickening. The soft tissues did not appear to be involved. Slight tenderness to moderate pressure was present. There was no inguinal adenopathy, or cutaneous discoloration, and the skin temperature was unchanged.

The roentgenograms taken July 7 showed ". . . still further proliferation of the periosteum and cortex. The fissure line is very distinctly seen now." (See Figure 2.)

Again pain and swelling subsided with bed rest. Temperature, pulse, and respiration were normal, and laboratory data were normal. He was discharged July 10, 1942.

The patient was seen in the Orthopaedic Clinic on November 4, 1942, at which time there was almost complete disappearance of pain and discomfort. The report of the follow-up roentgenograms follows:

"Examination at this time shows a definite decrease in the periosteal and cortical thickenings. The fissure line is very indistinct." (See Figure 3.)

Local examination was entirely negative except for slight bony enlargement in the region of the fracture.

The patient was again seen on February 1, 1943, and he reported that he was completely free from complaints. The bony enlargement, by this time, had completely disappeared. The report of the final roentgenographic examination was:

"There is still further reduction in size of the periosteal and cortical thickening. The fissure line is not seen at this time and there is complete bony union of the fragments."

FIG. 3

November 4, 1942, showing complete disappearance of the fracture line, with shrinking of the callus. The patient was symptom-free.

It is interesting to note that the diagnosis of an incomplete

fracture of the tibia was not determined until about one month following the onset of complaints. The periodic roentgenograms were diagnostically most important and succeeded in ruling out a neoplasm of bone, and made possible the diagnosis of an incomplete march fracture of the distal third of the right tibia.

Similarity to pseudofracture of the tibia must be mentioned.[2] Since the etiology of march fracture is undetermined, except for terms such as "wear and tear" or "physiological imbalance in the presence of persistent strain", it might not be amiss to group together cases spoken of as "march foot", "pseudofracture", "*Umbauzone*", and "wear-and-tear fractures", in view of their marked similarity in many respects, such as more common occurrence in youth, lack of inflammatory activity in most cases, and absence of definite trauma in many cases. In all of these conditions the lesion is benign, the physical findings are similar, and the roentgenographic appearances are similar at one stage or another. With increasing attention to this lesion, additional cases will probably be found in the lower extremities, especially among members of the Armed Forces.

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CONGENITAL TALONAVICULAR SYNOSTOSIS

A Case Report of a Rare Anomaly

BY D. H. O'DONOGHUE, M.D., AND L. STANLEY SELL, M.D.,
OKLAHOMA CITY, OKLAHOMA.

Congenital talonavicular synostosis was first described in 1879 by Anderson after he had discovered it in an anatomical dissection. He noted that the condition was bilateral, and that the articulating surface of the navicular was large. With the passing of three decades and the advent of roentgenographic diagnosis, another case was reported by Holland in which there were multiple fusions of the bones in one foot of a female, twenty-one years old. This foot showed a faint line of demarcation between the talus and the navicular, but all of the toes were present. Esau later reported upon a foot in which there existed a talonavicular-cuneiform fusion with absence of toes, and with no other deformities. Illievitz described another unilateral deformity, this one in a female with a combination talonavicular fusion and absence of the fifth toe. Hayek's patient had a unilateral talonavicular fusion, in combination with six toes and a first cuneiform bone which was smaller than the neighboring two. Another patient with a unilateral talonavicular fusion was a male, twenty-six years old; this case was reported by Blencke. There were no other pathological findings in this foot, although the roentgenogram did show some small residual islands of cartilage at the site of the usual talonavicular joint.

FIG. 1

Dorsoplantar view of both feet, which shows the talonavicular synostosis and only two cuneiform bones instead of three.

FIG. 2

Lateral view shows a large space at the navicular-cuneiform joint, evidently in compensation for the lack of a normal talonavicular joint.

Another case has been seen by the authors.

The patient, a white male, sixty-six years old, well-developed and obese, had experienced trouble with his feet since the age of sixteen. He complained of pain in the longitudinal arches of the feet, fatigue, and occasional cramping in the calves of the legs. Examination showed normal external configuration, good blood supply, fair arches, and no shortening of the heel cord. There was some limitation of motion through the midtarsus. Roentgenographic examination of the feet revealed bilateral talonavicular synostosis and two rather large cuneiform bones in place of the usual three. The rest of the bony architecture was essentially normal. The patient was fitted with substantial shoes, molded cork-leather arch supports, and a lift to the inner border of the heels. Within six weeks, he was relieved of pain and could carry on his normal activity without complaints.

This case is unusual, because the synostosis is bilaterally symmetrical. This is only the second instance in which it has been reported, and the first occasion where it has been substantiated with roentgenograms. Several of the previous writers have offered theories as to the etiology underlying this rare anomaly, but the most logical reason would appear to be a factor acting either to produce fusion of the primordial anlage, or to prevent its differentiation into separate bones. The cases which exhibited an increase, or decrease, from the normal number of metatarsals, or fusion of other tarsal bones, would be further evidence in favor of such an acting factor, and would be contradictory to the idea that talonavicular synostoses are in reality a congenital absence of the navicular, accompanied by compensatory hypertrophy of the talus. In crocodilia, the talus and navicular are one bone, and this fact could also be considered as evidence that talonavicular synostosis in man is a failure of differentiation, and represents reversion to a more primitive bone pattern.

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NOTE: The authors wish to express their appreciation for the aid of Dr. E. Lachman, Department of Anatomy, University of Oklahoma School of Medicine, in translating the references written in German.

FRACTURE-DISLOCATION OF A FUSED TRIANGULAR AND LUNATE (CONGENITAL)

Report of a Case

BY PAUL F. McGOEY, M.D., EAST KILBRIDE, SCOTLAND

From the Canadian Orthopaedic Unit, Hairmyres Hospital, East Kilbride

The following case is reported because of the rarity of the condition. The author has been unable to find a recorded incidence of this anomaly in the literature, and therefore presents this interesting example.

A member of the Royal Air Force, twenty-three years old, was referred to the Canadian Orthopaedic Unit four days after sustaining an injury to the carpus. The injury resulted from a severe impact which was transmitted along the axis of the forearm from the palm, with the elbow fixed.

Roentgenograms revealed the presence of a fracture of the posterior surface of the triangular portion of a fused triangular-lunate, with a dislocation of the carpus (Fig. 1-A). The flake of bone seen above the hamate (Fig. 1-A) was disclosed in the oblique view (Fig. 2-A). It has been difficult to ascertain the origin of this flake. A roentgenogram of the other carpus showed it to be normal.

Fig. 1-A

Anteroposterior roentgenogram of the carpus before reduction, showing the fusion of the triangular and the lunate, and the dislocation of the carpus.

Fig. 1-B

Anteroposterior roentgenogram of the carpus after reduction. Note the alignment of the carpal bones. Compare with Fig. 1-A.

FIG. 2-A

Roentgenogram, oblique view, before reduction, showing the prominence of the fused bones. Compare with Fig. 2-B.

FIG. 2-B

Roentgenogram, oblique view, after reduction. Note the position of the fused bones.

The dislocation was easily reduced by simple traction. The fragment could be felt on the dorsal surface, and was returned to position by molding the hardening skin-tight plaster.

The wrist was immobilized for ten weeks in skin-tight plasters, extending from the upper forearm to the metacarpal necks. At the end of thirteen weeks, the patient had full painless function except for the final five degrees of palmar flexion.

ANGIOMA OF THE TIBIALIS ANTERIOR

A Case Report

BY ISADORE ZADEK, M.D., NEW YORK, N. Y.

This is the report of a fourteen-year-old girl who was first seen by the author July 31, 1942, because of trouble with her right leg. This illness dated from the age of five years, when she was living in South Africa.

There was no history of injury. Pain developed over the outer aspect of the right leg after walking. This was associated with a peculiar gait. The pain was worse after strenuous exercise, and was very sharp when local pressure was made on the affected area. The location of the pain had always been constant. She had lost no weight. The symptoms had not changed.

Two years after the onset she was examined by the family doctor in South Africa. Later she was seen by a surgeon, and then by an orthopaedic surgeon in Capetown. Numerous roentgenograms of the affected leg had been taken, which had always been negative. When she was twelve, she had come to this country and had been seen by a surgeon here who could suggest nothing to give her relief. A great deal of physiotherapy had not improved the condition.

Examination showed that she walked without limp, but with a peculiar gait on the right. There was no limitation of motion in the right hip, knee, ankle, or foot; but on extreme flexion, the right hip rotated slightly outward.

Over the outer aspect of the right leg, in the middle third, between the tibia and fibula, anterolaterally, there was an area of local sensitiveness, the size of a silver half dollar. There was nothing abnormal in the skin on either inspection or palpation. No mass was perceptible nor could any swelling be seen when the light was projected from various angles. When this area was touched, pain was excruciating, and the patient, who was thoroughly cooperative, jumped violently. The pulses in both feet were normal. The knee and ankle jerks were active and equal on both sides. The right leg was one-quarter of an inch longer than the left.

The circumference of the right thigh was one inch less than the left, and the right calf was one-half inch smaller than the left.

Roentgenograms of the right leg and right hip were negative.

Dr. Samuel Brock saw the patient in consultation. No neurological disease could be demonstrated. He likewise suspected a local condition to explain the pain.

An exploratory operation was performed on November 17, 1942. A four-inch incision was made over the painful area, and nothing abnormal was found in the skin or subcutaneous tissues or when the fascial covering of the mass of muscles was split. Therefore the muscles were inspected individually. When the tibialis anterior was isolated, it did not bulge, but was locally resistant to digital pressure. The muscle belly was explored in the line of its fibers, and a tumor mass was found which was split in the same line; it was grayish-mulberry in color, and showed dilated spaces. It did not bleed freely, though the operation was not done under a tourniquet. The belly of the muscle was almost completely replaced by the tumor in this location. In order to remove it, it was necessary to transsect the muscle above and below. The tumor mass was almond-shaped and was an inch and one-half long.

The distal portion of the musculotendinous substance, after excision of the mass, was sewed to the deep fascia with interrupted chromic gut. The deep fascia and the subcutaneous tissues were closed with plain catgut, and the skin with silk. Soft dressings were applied.

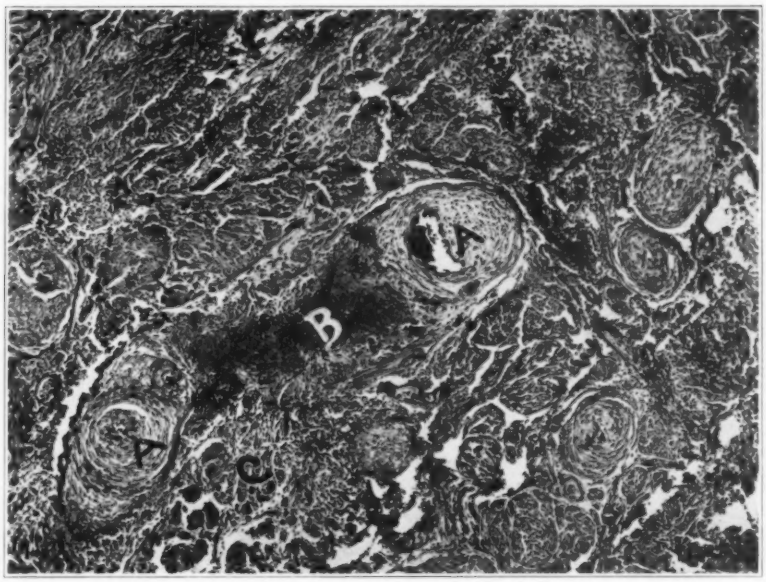

FIG. 1

Photomicrograph of a section from the muscle and tumor mass showing arteritis in small blood vessels (*A*), with dilated blood space and pigmentation (*B*), and, hyalinized muscle fibers (*C*).

The day after the operation, the patient volunteered the information that she had no more pain. Her surgical postoperative course was uneventful. A virus pneumonia developed two weeks after she left the hospital.

The operative incision healed by primary union and subsequent examination showed that this area could be pressed upon vigorously without eliciting any pain. Her spontaneous pain likewise completely disappeared.

Immediately after the operation, there was no action in the tibialis anterior. Gradually power returned, and the muscle now functions normally and shows normal power without dimpling of the skin at the operative site. No mass or induration is palpable at the operative site. Four months after the operation, the right calf was still one-half of an inch smaller than the left. Active motion in both ankles is the same. She walks without limp and her longitudinal arch is well maintained on the right, being as good as on the left.

Microscopic examination showed a vascular tumor in the muscle substance with an increase in connective tissue about the nerves and blood vessels, with dilated blood spaces, marked endarteritis, and lymphocytic infiltration. The muscle fibers in the vicinity of the tumor showed hyaline changes.

The complete return of power in the tibialis anterior, after excision of a segment an inch and a half long at the musculotendinous junction, was a pleasant surprise, and can be explained only on the basis of fibrous replacement.

CONSTANTINE LAMBRINUDI

1890–1943

Constantine Lambrinudi enjoyed a unique position in British surgery because he, more than any of his contemporaries, advanced the mechanistic concept of orthopaedic surgery. He was a man of striking personality and great charm, and his character was made all the more impressive by the absence of what many consider essential qualities in an orthopaedic surgeon of the first rank. Lambrinudi cared little for administration, and those who worked with him did so because they enjoyed it rather than as members of a departmental machine. It may have been that his physical disability compelled him to devote all his attention to what he loved most, leaving the rest to take care of itself. Eleven years ago, his health and even his life were endangered by heart disease; and when, to his own delight and that of his friends, he was allowed back to work, his activities were severely restricted for a long time, and all heavy physical effort had to be avoided. He knew that he would not live for many years, but in spite of this, perhaps because of it, he returned to his work with an infectious gaiety and unquenchable enthusiasm.

It may be that Lambrinudi's name is not widely known outside Britain. Here there was no antlike industry to leave a dusty monument of publications; his life was too short and too chequered by reverses. In any case humdrum work was distasteful to him; he had hardly any use for collected data, for statistics, or for the well-worn methods of pathological investigation. Once when he was asked to look at a section he said, "It's no use expecting me to see anything there, I'm color blind". Perhaps he was, yet the truth was that he cared little about the material structure of the body, but everything about its mechanism, about form in relation to function. Lambrinudi spent endless time studying the workings of the foot. Out of this labor came his conception of a stabilizing operation for drop-foot, and the first rational procedure for the correction of clawing of the toes in pes cavus—so well thought out that he predicted and proved that in the milder cases correction of the action of the toes would reduce the deformity of the arch itself—and his description of the condition which he called metatarsus elevatus. It was the same in his work on adolescent kyphosis and congenital dislocation of the hip. His recent advocacy of the teaching of orthopaedic surgery in the first clinical years sprang from a conviction that no knowledge of the body, in health or disease, could be complete without some understanding of the machinery of the limbs, the spine, and the body as a whole; and he undoubtedly put his finger on a weak point in medical teaching.

Late last year Lambrinudi made plans to write a book on orthopaedic surgery. It is lamentable that now it can never be written, for it might well have brought out his emphasis upon function and vital mechanics from beneath the shapeless mass of pathological data, carpenters' tricks, and shaky generalizations that we find in most textbooks on orthopaedic surgery and that obscure the fact that whatever else it may be, the greater part of the body is, in a literal sense, a machine.

There is, however, no need to fear that Lambrinudi will be forgotten. His many friends will always remember the refreshing vigour of his conversation, his boyish delight in discovery—whether the work was his own or another's—and his outspoken but good-humored contempt for humbug and hypocrisy. Very occasionally the chain of his physical weakness produced signs of chafing; but there was no bitterness in him, only regret that he could not do all that his eager spirit desired. While yet a medical student he had served the country of his birth in the Balkan wars. Just before the present war he played with the idea of going there again, to set up a national orthopaedic scheme. As he said, "I'd have a shot at being the Robert Jones of Greece". Lambrinudi succeeded Trethewan as orthopaedic surgeon at Guy's; he was recently President of the Orthopaedic Section of the Royal Society of Medicine; and he served two terms as a member of the Executive Committee of the British Orthopaedic Association. He held other offices, too. Yet these are only the professional trappings, and it is the man and his character that stand out in the remembrance of his colleagues who mourn his early death.

News Notes

The Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, Illinois, January 23, 24, 25, and 26, 1944, combined with the Annual Meeting of the **Clinical Orthopaedic Society.** Registration will begin Saturday morning, January 22, 1944, and a scientific motion-picture program will be offered Saturday afternoon. An exceptionally fine program of instructional courses will be given Sunday morning, afternoon, and evening. Monday morning will be given over to courses in Reconstruction Surgery, offered to all attending the meeting. Monday afternoon the Clinical Orthopaedic Society will hold its clinical program. The scientific program of The Academy will be presented January 25 and 26, and the Annual Dinner will be Tuesday evening, January 25. The instructional courses and scientific papers promise to make this the finest meeting ever held by this group.

Evidence of international recognition of professional achievement is always welcome. It is therefore with pleasure that the election of Dr. Elliott C. Cutler and Dr. Robert B. Osgood to honorary fellowship in the Royal College of Surgeons can be recorded.

Dr. Carl T. Harris of Rochester, New York, has moved his office to 213 Alexander Street.

Dr. David M. Bosworth announces the removal of his office to 742 Park Avenue, New York 21, N. Y.

Dr. S. Perry Rogers, formerly of Chicago, has opened his offices at 203 Roberts-Banner Building, El Paso, Texas.

The Wartime Conference and the Seventy-Second Annual Business Meeting of the **American Public Health Association** will be held in New York, N. Y., October 12 to 14. The Hotel Pennsylvania will be headquarters. Health workers within easy access of New York City are invited to attend. Representation of distant areas will be provided by individually appointed delegates.

The Local Committee in Charge of Arrangements is headed by Dr. Ernest L. Stebbins, Health Commissioner of New York City. Further information may be obtained from the American Public Health Association, 1790 Broadway, New York 19, N. Y.

The **Association of Military Surgeons of the United States** will convene in Philadelphia, Pennsylvania, October 21, for a three-day session in the Bellevue-Stratford Hotel, to mark the Fifty-First Meeting of the organization.

The symposium on war medicine will be of vital and direct interest to the health and welfare of the men in the Armed Forces, to physicians, research specialists, and scientists everywhere, as well as to the general public. It is expected that the meeting will bring together 2000 doctors, many of whom have been on active duty with the servicemen in every camp and base throughout the country and on all the fighting fronts. Representatives from many foreign countries are expected to be present.

The Honorary Chairman is Rear Admiral Ross T. McIntire, Surgeon General of the United States Navy. The General Chairman is Captain Joseph A. Biello, District Medical Officer of the Fourth Naval District. Further information may be obtained from the Association of Military Surgeons of the United States, Room 603, 1520 Locust Street, Philadelphia.

THE BRITISH ORTHOPAEDIC ASSOCIATION

A special meeting of **The British Orthopaedic Association** was held in London, February 27, under the presidency of Mr. G. R. Girdlestone, of Oxford. The organization of orthopaedic sections of military hospitals in the British Isles was discussed by Major R. Furlong, on behalf of Brigadier General W. Rowley Bristow. The close working of orthopaedic with general surgical teams was further elaborated by Lieutenant Colonel St. J. D. Buxton, who described the organization of the Orthopaedic Service in the Middle East Force. [Much of the material covered in these presentations has already been given to *Journal* readers in the article by Brigadier General Bristow, Volume XXV, page 524, July 1943.]

Colonel E. C. Cutler, United States Army Medical Corps, urged that surgeons sent to the forward areas should have had general training along with their specialty. Air transport makes it possible to evacuate patients requiring special treatment to hospitals where full orthopaedic facilities are available. Orthopaedic surgery, he said, has an important part to play in the application of its principles to the problems of trauma.

A series of short papers on various clinical aspects of military orthopaedic surgery were read:

Major Furlong, discussing four minor injuries, dealt first with "Churchill finger", an injury common in tank crews, in which the tip of one or more digits is crushed by the sudden closure of the roof-flap. He advised covering the ends of the fingers by whole-thickness skin-grafts, with loose dressings to avoid rigid immobilization and consequent stiffness. In fractures of the metacarpals, Major Furlong said the contusion of the hand was of primary consideration, and attention should be paid to restoring function in the soft tissues, rather than to splintage. Return to duty after Bennett's fracture of the base of the thumb is quicker and more satisfactory if no reduction is attempted. For fracture of the clavicle, autoreduction by the soldier is advocated, employing the hips-firm-shoulders-back attitude, during which a figure-of-eight bandage is applied over both shoulders, without padding, to ensure keeping the shoulders back. Early movement, and return to light duty at the end of three weeks is the rule.

Lieutenant Colonel Buxton reviewed the simple "Method of Charting for Peripheral Nerve Injuries" employed in the advanced areas of the Middle East, complete diagnosis based on exact investigation being left until later.

Major G. Perkins read a paper on the "Surgical Treatment of Osteomyelitis, the Result of Penetrating Wounds". The osteomyelitis pursues one of five courses: (a) the inflammation may resolve and never again trouble the patient; (b) it may continue as persistent acute osteomyelitis; (c) the acute inflammation may subside, leaving a sinus down to the interior of the bone; (d) it may heal, but after months or years may recur; (e) there may be a persistent sinus associated with recurrent "flares" of acute inflammation in the bone. In persistent acute osteomyelitis, surgery is rarely necessary for the cure of the inflammation; drainage is usually adequate because of the wound. Later, amputation may be advisable, either to save life or because an artificial limb will be more useful than a crippled leg, in patients who have an ununited fracture or serious unsuturable nerve lesions or loss of soft tissue. A sinus may remain because of the presence of a foreign body or sequestrum; this needs careful exposure of the cavity without excision of the track which has been opened up, removal of dead fragments, and light suture without drainage. Sequestra and foreign bodies are not always revealed roentgenographically, and it is often difficult to decide when inflammation has subsided enough to permit interference. The sinus may persist from continued mild infection without sequestra. Here the object is to remove all infected bone, though this may not be entirely practicable. The obliteration of cavities is important; no more than half the circumference of the infected bone should be chiselled away, care being taken not to fracture the bone. The immediate sequel is acute inflammation of the bone that is left, and there must therefore be free drainage by light packing with paraffin-soaked gauze, which should be removed as soon as a "safety valve" is no longer needed. For recurrent attacks of acute osteomyelitis Major Perkins advocated conservatism, the

essential treatment being rest; surgery is not indicated unless an abscess forms, and then only if an exit for pus is necessary. A sinus with recurrent flares as a rule defies treatment. Usually there is a continuous grumbling inflammation in a bone riddled with organisms. The more serious cases in the lower extremity amply justify amputation, which should first be done through the lowest limit of healthy bone. When all sepsis has been eliminated, the final amputation is done at the site of election.

Major T. T. Stamm, discussing "Injuries to the Knee Joint", said that the soldier regards the operation for removal of a torn semilunar cartilage with suspicion, because of poor results with other patients, due to inaccurate diagnosis or mistaken judgment in immediate or postoperative treatment. In diagnosis, the joint should be examined under intravenous anaesthesia. The injury most often missed is a lesion of the anterior cruciate ligament. This may be the only lesion present; it is then nearly always possible to lock the joint and unlock it while performing the diagnostic test elaborated by Lambrinudi. In treating patients with minor damage, mistakes may result, since the knee is held flexed by spasm of the hamstrings, which may be mistaken for locking of the joint. In patients treated late, there are two groups of symptoms,—those due to the lesion itself, a feeling of insecurity and that the knee "comes forward" suddenly when under load in the semiflexed position, with no actual locking; and those due to slipping of one or another cartilage, usually the medial, producing momentary locking as the main feature. In spite of the symptoms, no lesion of the cartilage will be found at operation in such cases. Operation may be justified where repeated attacks of locking cause severe disablement, but as a general rule it should be avoided, for the results are not good. With true cartilage tears it is important to differentiate between tears of the substance of the cartilage and peripheral detachments of the cartilage from the capsule. The former occur in the non-vascular material and therefore produce less reaction, but healing is impossible. In the latter, the reaction (hemarthrosis, tenderness, etc.) will be severe, because of the vascularity and sensitivity. Thus, those injuries which appear more severe do best with conservative treatment and heal well, whereas the apparently less severe lesions more often require operation. In the postoperative treatment, the fact is often overlooked that removal of a cartilage completely upsets the lubricating mechanism of the joint; much longer convalescence is required than is usually allowed. Patients with internal derangements of the knee should be sent to the hospital at once.

The need for early, accurate diagnosis was stressed in a discussion of "Fractures of the Carpal Scaphoid" by Major G. D. Rowley, who reviewed 450 cases. Difficulties arise from delay in diagnosis, and imperfect suspension and immobilization. Fractures in the proximal third and those with displacement of fragments appear to have a poor prognosis. It is questionable whether a graft is ever justifiable in a private soldier. Sometimes a delayed union will unite if the wrist is immobilized long enough. For recent strains in old-standing lesions, plaster immobilization for four to five weeks will often relieve symptoms. If a soldier does not have a perfect result, he will find difficulty in handling a rifle or ammunition as a member of a gun crew.

Mr. C. Lambrinudi brought forward important new evidence concerning the mechanics of the carpal joints in relation to displacement of the scaphoid fragments, which he showed to be associated with a minor degree of subluxation of the lunate bone. The cystic appearance seen in some fractures of the scaphoid is due to opening up of the fracture gap. Accurate reduction of all scaphoid fractures and of the intercarpal subluxation is needed before the application of plaster fixation.

Major Soto-Hall, United States Army Medical Corps, demonstrated a manoeuvre for achieving impaction. In fractures of the right scaphoid, the surgeon provides counter-pressure with his left hand against the lower end of the humerus with the elbow flexed, while he presses the first interosseous space of his right hand against the interosseous aspect of the patient's first metacarpal, forcing the patient's wrist into slight dorsiflexion and radial abduction. Plaster is applied in this position, including the interphalangeal joint of the thumb. Over 90 per cent. of perfect results should thus be obtained.

After the reading of the clinical papers, Mr. R. Watson-Jones presented a report on

behalf of the Executive Committee, dealing with the future of accident services; this was approved by the Association. The B.M.A. Fracture Committee in 1935, and the Delevingne Committee in 1939, recommended the development of special fracture services based on the principles of segregation of cases and continuity of treatment and after-care under a unified control. The comprehensive accident service of the future should embrace the treatment of soft-tissue injuries, infections of the hand, burns, tendon injuries, nerve injuries, and all injuries of the locomotor system. These injuries are no less incapacitating than fractures, their importance to industry is just as great, and they outnumber fractures by five or ten to one. The problem will be solved more readily by the reorganization of accident departments of general hospitals than by the formation of special accident hospitals. The accident department must be reorganized, replanned, and often rebuilt. There must be a separate organization and even a separate entrance for accident patients. The director of the accident service should be trained in every branch of surgery, experienced in orthopaedic surgery, and specially trained in the problems of trauma. It would be inadvisable to develop "traumatology" as a new branch of surgery, or to train "traumatic surgeons" whose skill would be disseminated over the vast fields of locomotor, abdominal, thoracic, faciomaxillary, ophthalmic, and cerebral surgery. Since the accident unit must provide a twenty-four-hour service, the director must be aided by two first assistants, in addition to the usual resident surgical officers, house surgeons, and house physicians. There must be full secretarial and clerical assistance, and almoners or social service personnel. Close liaison must be established with industrial medical officers in the area served by the unit. The rehabilitation of sedentary and light industrial workers can usually be completed within the hospital itself by physiotherapy, occupational therapy, and recreational therapy; for the rehabilitation of more seriously injured patients who must return to heavy industry, the accident service must have a special rehabilitation annex with playing fields, swimming pools, and gymnasiums. Such special centers are essentially medical units where treatment is continued by the same team, and they must remain under the same administration and surgical control as the parent hospital.

The Spring Meeting of **The British Orthopaedic Association** was held in Glasgow, May 14 and 15, under the presidency of Mr. G. R. Girdlestone, of Oxford.

In an analysis of twenty-one cases of spinal-cord injury admitted to the Killearn E.M.S. Hospital, Mr. R. C. Murray said that the neurological lesion can usually be accounted for by a study of the roentgenograms, but where these show no adequate cause, there may be a protrusion of bone from the back of the vertebral body which is a possible indication for early laminectomy. In cord lesions with complete loss of function lasting twenty-four hours, no recovery can be expected in segments below the lesion. The chance of recovery is best in cervical lesions and those below the first lumbar vertebra. There is no limit to the time of recovery of motor fibers in the roots and cauda equina. Reduction should be carried out in all cases, for even in complete cord lesions this may lead to the recovery of some roots and so add two or even three useful segments. Reduction should be followed by fixation,—in the cervical region by continuous skeletal traction, after operative reduction by a hyperextension plaster jacket, and in cauda lesions by a plaster bed and turning case. The greatest difficulty, on account of pressure sores, is in dorsal lesions, for which a complete combined plaster jacket and double spica is advisable, so as to distribute pressure evenly, facilitate turning, and relieve pain and spasm. For treatment of the bladder, Mr. Murray recommended tidal drainage. He felt that few cases should be regarded as hopeless, for even with a complete lesion at the level of the conus a patient may learn to walk.

Mr. Roland Barnes, reporting on a similar group of patients, stressed the importance of accurate sensory testing in assessing the degree and prognosis of the spinal-cord injury; this is more valuable than knowledge of the extent of motor paralysis. The prognosis is worse in lesions at the level of the twelfth thoracic than of the first lumbar vertebra. Laminectomy is never indicated as an immediate operation, but should be done when

there is an incomplete paraplegia not showing spontaneous recovery; if there is evidence of increasing pressure on the cord; or for severe and intractable root pain. Reduction of vertebral displacement should always be attempted, particularly if the paraplegia is incomplete. Roentgenograms of the highest quality are essential. Fracture-dislocations with locked facets are commoner than is generally realized. For this injury an open operation is required; the excision of articular processes should be avoided, so as to maintain the stability of reduction, which usually should be further assured by internal fixation. For such operative cases Mr. Barnes prefers a plaster bed and turning case. For paralyzed bladder he condemned manual expression or an indwelling catheter; suprapubic cystotomy is indicated under field conditions, in irreparable spinal-cord injuries above the sacral segments, or where for any reason tidal drainage is impracticable.

Professor Noah Morris discussed "Phosphatase in Diseases of Bone" and said that, if jaundice is excluded, an increase of plasma alkaline phosphatase is indicative of the presence of bone disorder. Ordinarily, plasma phosphatase increases during periods of growth, where there is increased activity of osteoblasts. His hypothesis was that, if ossification is not maintained at a rate sufficient to meet the degree of cellular activity on which phosphatase formation is dependent, excess of ferment passes over into the plasma. In one case, studied with Mr. Matthew White, he found a considerable rise in plasma phosphatase where there was a defective supply of calcium. Woodard and his coworkers showed that, with primary tumors, plasma phosphatase increases only when the tumor cells are producing phosphatase much quicker than normal bone does, and that a fall of plasma phosphatase after surgical removal or irradiation therapy is due to the withdrawal or inactivation of the phosphatase-forming cells. In bone metastases, the increase of plasma phosphatase appears to be due to a defense reaction manifest as increased bone formation adjacent to the tumor cells. Only when the reaction is osteoplastic does the serum phosphatase increase; in osteolytic lesions, little alteration is observed. In many pathological conditions of bone—such as rickets, osteomalacia, and Paget's disease—the variations of plasma phosphatase afford a valuable guide to the course of the disease, the prognosis, and the effect of any therapeutic measure. An increase of acid phosphatase in the plasma is almost invariably derived from prostatic glandular epithelium. Prostatic phosphatase is high in the plasma only when the blood and lymph vessels are invaded by tumor cells derived from the prostate. Serial determinations of plasma acid phosphatase are of special value in assessing the results of castration or estrogen therapy.

In a paper on "The Control of Infection in Burns", Dr. Leonard Colebrook discussed coccal and bacillary infections. In 310 cases of burns admitted to the special unit of the Royal Infirmary, Glasgow, the methods used to obtain improved results included strict aseptic precautions during the first few hours following admission, with the use of sterilized blankets; an attempt to sterilize the burned surface with "CTAB" solution (without anaesthesia); the application of a bacteriostatic dressing which could be left undisturbed for seven to ten days (sulphanilamide or sulphathiazole, in lanette wax SX and castor oil base,—10 per cent. for most cases, 3 per cent. for extensive burns); prompt elimination of hemolytic streptococci from burns already infected, by means of penicillin or propamidine; and reduction of cross infection,—strict "no-touch" dressing technique, masks, and elimination of dust.

Mr. James Patrick, in a paper on "Supination and Pronation in Forearm Fractures", said that when a fracture of the forearm bones has been well reduced, limitation of movement is only to be feared in severe fractures of the head of the radius, and in fractures lower down in either bone where the attachment of the interosseous membrane is involved by fibrosis, ossification, or shortening. It is important to realize that the axis of radial rotation is exactly along the interosseous ridge of the ulna. He stressed the importance of lesions of the triangular fibrocartilage at the inferior radio-ulnar joint, not only in Colles' fracture, but also in fractures of the head of the radius, where early active rotation movements are advisable after the head has been excised. In fractures of the shafts of the radius and ulna, operation should be avoided as far as possible; where necessary,

only the radius should be exposed and its interosseous aspect should not be encroached upon. When cross union occurs in the lower third of the forearm, excision of a segment of the ulna, including the fracture, gives good results. For permanently severe loss of rotation after Colles' fracture, excision of the lower inch and the articular portion of the ulna is also good. Late angulation of fractures of both forearm bones is due to wasting of the brachioradialis muscle which allows sagging of the fracture within the plaster case; adequate support in the middle of the forearm avoids this complication.

Mr. I. S. Smillie, in a paper on "Regeneration of the Menisci of the Knee Joint in Man", described the fibrous structure which partially replaces an excised meniscus. It is densely adherent to the synovial membrane at its periphery; it is thinner and narrower than the normal structure and is whiter because it is composed of fibrous tissue only. In five cases, regenerated "cartilages" were torn, a circumstance which is rare unless factors producing gross instability are present within the joint.

Dr. G. W. Armstrong, of the Canadian Orthopaedic Unit, with a cinematograph film, described his method of internal fixation by screws in carefully selected cases of "Oblique Fractures of the Tibia", demonstrating the importance of a precise technique with perfect equipment.

Mr. Athol Parkes read a paper on "Traumatic Ischaemia of Peripheral Nerves" occurring in a group of patients in whom a severe injury to the leg, with or without fracture, had been followed by gross swelling of the limb and anaesthesia of gradual onset spreading centripetally from the great toe over the foot and ankle. Later, objectively, paralysis with the reaction of regeneration was observed in all the intrinsic muscles of the foot, with sensory loss in the distribution of all the deep nerves. Recovery is very slow. The cause of the condition may be tension under the deep fascia due to extravasation of blood and tissue fluids, causing ischaemia of the nerve trunks by pressure. Early operation is required, even when the peripheral pulse is present. Incisions through the deep fascia will relieve tension and prevent the development of an extremely disabling condition.

Clinical demonstrations were given at the Glasgow Royal Infirmary and the Phillipshill Orthopaedic Hospital. At Phillipshill, Dr. A. K. Bowman, introduced by Mr. James Russell, described the influence of Glasgow in the development of orthopaedics, particularly in relation to the work of the Hunters, of Lister, and of Macewen.

Current Literature

AN ATLAS OF ANATOMY (In Two Volumes). Volume I. UPPER LIMB, ABDOMEN, PERINEUM, PELVIS, AND LOWER LIMB. J. C. Boileau Grant, M.C., M.B., Ch.B., F.R.C.S. (Edin.). Baltimore, The Williams and Wilkins Co., 1943. $5.00.

From The Williams and Wilkins press in Baltimore has come the first of a two-volume Atlas of Anatomy. This should be welcomed by all students of the subject as well as by all practitioners. Following the customary order in the dissecting room, the well-legended drawings, made by an artist from carefully taken photographic studies of each subject, are so arranged that the student can easily follow the sequence as he turns the pages. The reproductions are beautifully done, and the care exercised in preparing the photographs for the artist's use guarantees their accuracy.

The author and the publishers are to be congratulated for their contribution.

MEDICAL CLINICS ON BONE DISEASES. A TEXT AND ATLAS. I. Snapper, M.D. New York, Interscience Publishers, Inc., 1943. $10.75.

In *The Journal* for July 1939, a review of "Maladies Osseuses" designated it as a "remarkable work on bone diseases . . . presenting material of unusual value, with unexcelled illustrations". This valuable book is now made available in English, and will, therefore, reach a much wider audience.

At the time of the first edition, Dr. Snapper was Professor at the University of Amsterdam. Since then he has served on the faculty of Peiping Union Medical College, and this American edition includes an additional chapter on Avitaminosis D, based largely on his study of deficiency diseases in China. The excellent reproduction of roentgenograms in this chapter is an important factor in his discussion of osteomalacia, foetal rickets, late rickets, and osteogenesis imperfecta.

All of the unusual illustrations, which were such a striking feature of "Maladies Osseuses", have been reproduced in this new edition. The same orderly presentation of each subject has been followed,—clinical syndrome, pathogenesis, biochemical analysis and blood picture, roentgenographic studies, differential diagnosis, case records, discussion, and bibliography. Each chapter is, therefore, quite complete, presenting such conditions as von Recklinghausen's Disease, Hyperplasia of the Parathyroids Secondary to Other Diseases, Paget's Disease, Lipoid Granulomatosis, Gaucher's Disease, and Multiple Myeloma.

As the Preface states, "In this book are presented observations and x-ray pictures specially chosen to elucidate some of the problems involved in the recent expansion of our knowledge of bone diseases". The author has succeeded well in this undertaking, and the result is a book of great value to all who are working in this field.

PAIN MECHANISMS. A PHYSIOLOGIC INTERPRETATION OF CAUSALGIA AND ITS RELATED STATES. W. K. Livingston, M.D. New York, The Macmillan Company, 1943. $3.75.

Pain is the most universal of all symptoms. It is the primary cause for man's seeking health from the medical profession. Whatever branch of medicine is practiced, pain occurs in every doctor's life so frequently that any light thrown upon this symptom is welcome. Many have tried to explain pain, but few have succeeded in doing more than pass into the descriptive stage. Presumably all pain is appreciated only in the cortex of the brain in areas posterior to the Rolandic fissure, but what is the function of the great sensory organ of the basal ganglia, the thalmus? Is pain appreciated also at this level? Can pain be initiated by lesions of the pathways within the spinal cord? What is the exact nature of the peripheral pathways that carry the pain sensations, and what

kind of damage to them will cause such a remarkable series of events as those evident in causalgia? Why should some amputation stumps be painful and other cases exhibit only painful phantom limbs?

The author of this monograph has studied these questions for a long time. He has not only reasoned in regard to them, but has carried out extensive experimental and clinical investigations. He is one of the leading workers in this field, and his book, the result of many years of experience, is a thoughtful summary of his present position. The volume covers briefly his physiological investigations, but is largely concerned with an analysis of his case reports which are used as a basis for discussing such subjects as causalgia, reflex paralysis, chronic low-back disability, facial neuralgias, and phantom limbs.

A final section of the book deals with the writer's interpretations, and, in his summary, he modestly states that no final conclusions can be drawn from this study of pain mechanisms in the causalgic states. He has, nevertheless, certain convictions which have grown with the years. One is that the concept of specificity, in the narrow sense in which it is sometimes used to identify sensory experiences with particular end organs and nerve fibers, has led us away from a true perspective. He thinks it a mistake, moreover, to assume that a certain pain syndrome must represent an obsession or be of purely psychic origin, simply because its manifestations do not conform to what we have always been taught about anatomy and physiology or peripheral nerve pathways. He would not discredit, in addition, the effects of periarterial sympathectomy, and novocaine injection even though their mode of action is obscure. Finally, Dr. Livingston believes that the whole story of causalgic states will not be learned from a study of the functions of the sympathetic nerves.

This book is a dignified, thoughtful essay. The author is modest in regard to his claims of throwing any light upon the subject. One feels, however, that his summary of the literature and the additional knowledge which he has given to the subject are well combined in this book, which should be of value to all members of the medical profession.

THE PRINCIPLES AND PRACTICE OF WAR SURGERY WITH REFERENCE TO THE BIOLOGICAL METHOD OF THE TREATMENT OF WAR WOUNDS AND FRACTURES. J. Trueta, M.D. With introduction by Owen H. Wangensteen, M.D. St. Louis, The C. V. Mosby Co., 1943. $6.50.

The author of this book is particularly well qualified to write on war surgery; he was Director of Surgery at the General Hospital of Catalonia, Barcelona, during the recent Spanish Civil War. The extensive experience which the author gained in this conflict has been increased and ripened through his connection with the Wingfield-Morris Orthopaedic Hospital, Oxford. In this institution he has seen and treated many of the late results of injuries sustained in World War II.

The book must be read to be appreciated. Its preface definitely contributes to an understanding of the volume. Trueta is grateful for the kindly reception that he has received in England, and acknowledges his indebtedness to his Oxford colleagues in particular. Concerning his indebtedness to the American surgeon, H. Winnett Orr, who, by his pioneer work, lighted the path that Trueta followed, Trueta's own words are: "I have proclaimed this before, but there is no other or more fitting note on which I would wish to introduce this book". This is of interest because certain surgeons have tended to credit Trueta with originating the so-called plaster technique, and more or less to ignore the pioneer work of Orr. Trueta squarely states the facts, indicating a fairness and friendliness of character that is always refreshing to encounter.

The book is in two main parts. The first part is devoted to a discussion of the pathology of war wounds and the general care of the wounded. Briefly included here are the history of war surgery, the healing of wounds, the passage of bacteria and their toxins through the body, gas gangrene, tetanus, shock, crush injuries, and so forth.

The second part is the important section of the book. Therein Trueta gives his conception of the biological treatment of wounds, basing this conception on five funda-

mental points: (1) prompt surgical treatment; (2) cleansing of the wound; (3) excision of the wound; (4) provision for drainage; and (5) immobilization in a plaster-of-Paris cast. These are discussed in satisfying detail. In the chapter on antiseptics the author emphasizes the fact that application of antiseptics after the infection has occurred is generally useless and leads to false reliance on the power of the agent used. If possible, the agent should be applied before, or at the same time as, the infection is introduced. Trueta is dogmatic in the statement that there is no alternative for careful cleansing of the wound with soap. He declares that a 5-per-cent. solution of ricinoleate or coconut soap, with a pH no higher than 7.5, is strong enough to destroy bacteria, but that it does not damage or irritate the living tissue cells. The remainder of this portion of the book is taken up with chemotherapy, wound excision and drainage, reduction and fixation of fractures, immobilization, plaster-of-Paris technique, primary and secondary suturing, skin-grafting, treatment of articular wounds, amputations, regional surgery, and burns.

The use of plaster-of-Paris in the care of the war casualties (it must be remembered that the author is writing of war injuries only) is carefully described. He recommends application of a plaster cast directly to the skin, without padding, and, if drainage is required, he uses a good grade of gauze bandage of close mesh. He does not use vaseline gauze and does not pack the wound open. He allows the muscles to fall together and merely brings the gauze drain up to the surface; there it comes in contact with the plaster-of-Paris, which acts as a good hygroscopic agent. On the day following application of the cast he likes to see copious discoloration of the plaster with the drainage from the wound as an indication that the secretion is finding its way out. He mentions the odor following drainage into the plaster, but pays it little attention. He suggests using a bootlet or armlet made of a new material developed in England, which is impregnated with charcoal to act as a deodorant.

Trueta draws attention to his previous work in collaboration with Barnes, wherein it was demonstrated that the movement of lymph is distinctly less when an extremity is held quiescent in a plaster-of-Paris cast. For that reason Trueta feels sure that rest helps to prevent not only the spread of infection but also of toxins.

Trueta's indications for the use of sulfonamide compounds in war surgery are as follows:

1. In all cases in which complete surgical treatment of war wounds must be delayed, sulfonamide compounds should be given at the earliest possible moment.

2. If early operation is possible and if excision of the wound has been complete, local application of the drug, he says, seems to be a useful adjunct to the surgical technique. He mentions penicillin, but evidently has had little experience with it because he states that it is a new substance and "may prove useful" in combating a diversity of infections.

The book is well constructed. There are frequent headings; the paragraphs are short; the print is good; and the illustrations are well chosen—all contributing to easy perusal. It is a book that all surgeons interested in war surgery (and these days there are many) should study. After reading the book, the impression remains that war-wounded patients need no longer be harrowed by frequent dressings, attended as they are with the risk of secondary infection. The modern surgeon, in dealing with war injuries, supports nature's efforts rather than substituting his own methods.

MANUAL OF FRACTURES. TREATMENT BY EXTERNAL FIXATION. C. M. Shaar, M.D., F.A.C.S., and Frank P. Kreuz, Jr., M.D., F.A.C.S. Philadelphia and London, W. B. Saunders Company, 1943. $3.00.

This small volume on the subject of the external treatment of fractures, prepared by two Naval medical officers, has of course its greatest appeal to Navy medical personnel for the reason that the customary traction and plaster-extension methods are quite inapplicable on a rolling ship at sea, where quick evacuation of the wounded may be necessary. Furthermore, the internal-fixation methods, dependent as they are upon

perfect asepsis and the team work of a group trained by long experience, are equally impracticable.

Concentrating on perfecting the technique of applying external fixation suitable for Naval use, these officers have succeeded in bringing Stader's splint to the attention of traumatic surgeons in a way that demonstrates its efficiency in a very understandable manner.

Numerous excellent illustrations make perfectly plain every step in the application of the method to every type of fracture.

With this book at hand, it should not be difficult for any well-trained operating surgeon to apply this method to the treatment of cases where it would ensure a better result than the more difficult technique of internal fixation, complicated as it often is by infection, or the traction and plaster-fixation methods that are more tedious and more liable to result in loss of, or tardy return of, motion in joints near the fracture line.

Both the authors and the publishers are to be congratulated on having accomplished their task most successfully.

MEDICAL MALPRACTICE. Louis J. Regan, M.D., LL.B. St. Louis, The C. V. Mosby Co., 1943. $5.00.

This book not only discusses questions of medical malpractice, but exemplifies by legal references and illustrative cases the great variety of missteps that are possible in the practice of medicine and surgery. It also cites and illustrates the many legally technical pitfalls that may border the pathway of even the carefully stepping doctor. To illustrate what may constitute malpractice, fifty actual cases are briefly cited of failure of the physician or dentist or nurse to fulfill the legal duty owed to the patient, with resulting injury to the patient.

The book is divided into fifteen chapters and sixty-seven sections. The most important chapters deal with malpractice vulnerability and malpractice prophylaxis. Examples of forms for "Consent to Operation", "Consent for Autopsy", "Consent to Disclosure of Privileged Information", "Patient Leaving Hospital Against Advice", "Acknowledgment of Hazards of Particular Therapy", and for "Obstetrician Unable to Be Present at Delivery" are furnished. The documentation of cases is remarkable, and includes twenty-seven pages of lists of legal references. The abstracts of illustrative cases are concise and clear. The discussions are as relatively free from technicalities as is possible; the approach is from the standpoint of the doctor, not the lawyer, and the case method of presentation adds interest to the subject. The book can be highly recommended.

THE MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. SIXTY-FIRST YEAR, 1943. Bristol, John Wright & Sons, Ltd., 1943.

The 1943 edition represents the sixty-first year that the British Medical Annual has been published. As those who are familiar with the Annual know, it is a year book of treatment and a practitioner's index. This issue, as has its predecessors, presents anything new which has developed in therapy during the preceding year. In spite of wartime restrictions imposed on all publishers, the book has 432 pages, with forty-five plates in addition to numerous smaller illustrations. The subject matter is varied, covering nearly every phase of medical or surgical treatment. The book's greatest value to the practising physician is as a reference book to which he may turn for the latest practice in the British Isles for any condition which may be of interest.

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS. Edwin O. Geckeler, M.D. Ed. 3. Baltimore, The Williams & Wilkins Co., 1943. $4.50.

In the past few years several small monographs have appeared upon the subject of fractures. It is characteristic of the monograph form that the author usually confines his description to that method of treatment with which he is most familiar.

The author has mentioned all the most important matters under each anatomical heading. The book is well written, and may be safely used as a guide to the treatment of fractures and dislocations found in daily practice. This is the best short book on fractures that has come to the reviewer's attention.

CIRUGÍA PLASTICA. Lelio Zeno. Buenos Aires, El Ateneo, 1943.

This publication should indeed be welcomed by those who wish an authoritative book on plastic and reconstructive surgery, written in Spanish.

The author has evidently an abundant personal experience, and has drawn, as well, from leading contemporary authorities in this field. The book is concise, and well illustrated. It covers the entire field of reconstructive surgery with chapters on wounds; burns; scar contractures about the eyes, mouth, and joints; injuries with loss of tissue; and plastic surgery of the nose, ears, face, hands, breasts, nerves, and tendons. Special attention is given to the correction of congenital anomalies and acquired defects, and the relation of the patient's psychological reaction to them.

The book compares very favorably with anything written in the English language, which the reviewer has seen.

COMMINUTED FRACTURES AND FRACTURE DISLOCATIONS OF THE BODY OF THE ASTRAGALUS; OPERATIVE TREATMENT. Harry C. Blair. *The American Journal of Surgery*, LIX, 37, January 1943.

The author presents a new type of fusion operation for fractures of the astragalus, as well as for fracture-dislocations which are followed by severe disability. The author states that neither astragalectomy nor the panastragaloid fusion have offered satisfactory results, and this is the reason for presenting this type of fusion.

The technique consists simply in the preparation of a sliding graft on the anterior surface of the tibia. This graft should be about one inch wide and about two inches long. Then a hole is made about three-quarters of an inch deep in the body of the astragalus, just large enough so that the end of the graft can be embedded firmly into the hole. No cartilage is removed from the articular surface of the tibia, except that which is attached to the distal end of the graft. The graft is held in place in the tibia by catgut. The foot is then placed in 100 to 105 degrees of equinus and a cast is applied. Ten to fifteen days after the operation, the cast is removed, a non-padded walking cast, equipped with a walking iron, is applied from the knee to the toes, and the patient is encouraged to walk as soon as he is able to bear weight.

The advantages of this operation, as described by the author, are that it does not change the outward appearance of the foot. Also, backward displacement is not necessary. In fact, the relationship of the foot to the ankle and the leg remains practically normal. There is no shortening of the extremity. Weight-bearing thrust is placed on normal undisturbed tissue. In astragalectomy, on the other hand, tissue not intended for weight-bearing is called upon to carry out this task. The fusion operation which the author describes actually does allow flexion and extension of the foot on the leg. The two subastragalar facets and the astragaloscaphoid joint allow a rocking movement of greater or lesser degree.

Another consideration is that there is no tendency toward the development of lateral deformity of the foot. It is, therefore, suggested that this procedure might also be considered in those cases in which paralytic calcaneus deformity is present, without impairment of the lateral muscle groups.—*T. J. Greteman, M.D., Iowa City, Iowa.*

O MÉTODO QUIMIOFISIOTERÁPICO NAS OSTEOMIELITES (On the Chemophysiotherapeutic Method in Osteomyelitis). Francisco Finocchiaro. *Anais Paulistas de Medicina e Cirurgia*, XLIV, 95, 1942.

The author used a combination conservative treatment of surgical tuberculosis, consisting of injections of Durante's emulsion (10-per-cent. solution of iodoform in almond

oil) and subsequent irradiation of the involved areas. Extending this method to the treatment of osteomyelitis in general, in children and adolescents he succeeded in obtaining cures within periods of three months to two years. The abscesses were aspirated and immediately injected with Durante's emulsion, and then exposed to roentgenotherapy in doses inversely proportional to the acuteness of the inflammatory process. In cases where the injection of Durante's emulsion was impracticable, colloidal silver was injected intravenously, and the irradiation was applied locally. This method, by eliminating injury to the growing epiphysis, and operative risk and mutilations, should, in the author's opinion, be preferred to open operations.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LESS COMMON LESIONS OF THE ASTRAGALUS. Raymond W. Lewis. *Annals of Surgery*, CXVI, 891, 1942.

The author reports eight cases of the less commonly encountered lesions of the astragalus, to call attention to the wide variety of pathology occurring in this bone. He reports the following types of cases:

Tuberculosis of the astragalus in a boy of two years;

Staphylococcus osteomyelitis of the astragalus, with involvement of adjacent joints in a boy of seven;

Osteochondritis dissecans in a man;

Aseptic necrosis of the body of the astragalus with crushing of the body, probably secondary to the circulatory disturbance following trauma, in a girl of six;

Osteochondroma in a boy of fourteen years;

Osteitis fibrosa cystica with scattered giant cells in a girl, aged eleven years;

Chrondromatous giant-cell tumor in a man of thirty years;

Metastatic adenocarcinoma, most probably primary in the breast, in a woman fifty years old.

CLAVICLE FRACTURE TREATED WITH SKELETAL TRACTION. Ross Sutherland and M. John Rowe, Jr. *Annals of Surgery*, CXVI, 950, 1942.

To obtain reduction, early healing, and final cosmetic result, with comfort to the patient with fracture of the clavicle, the authors utilize skeletal traction. Through a small incision, made under general anaesthesia, the wire is placed in the outer end of the clavicle, and a clevis is applied and is attached, with traction, to a floor frame. The patient is placed supine in a standard hospital bed with the head slightly elevated.

Two cases are reported.

A METHOD OF FIXATION FOR FRACTURES OF THE STERNUM. L. H. McKim. *Annals of Surgery*, CXVIII, 158, July 1943.

Fractures of the sternum are comparatively rare. The stooping posture of the patient is characteristic, and substernal pain associated with dyspnea is suggestive of the injury. There may be deformity, which may be obscured by swelling, and localized tenderness at the point of injury. The tenderness may be more widespread, due to concomitant injuries to the sternochondral articulations. Satisfactory roentgenograms are difficult to obtain. Some fractures can be reduced by manipulation in the position of upper thoracic hyperextension; others require open reduction and possibly fixation.

The author reports a case of an officer who had received multiple lacerations and contusions of the face, scalp, right arm, and anterior chest wall. He complained of pain on compression of the upper chest.

Nine days after injury, under local anaesthesia, a short curved incision was made about one inch below the point of fracture. The depressed portion (manubrium) was elevated, but reduction could not be maintained. One Kirschner wire was inserted

about two inches below the incision, and was passed upward through the body of the sternum, across the fracture line, and superficially into the manubrium. A second wire was passed transversely through the sternum and into the end of the second rib on the right side. The second wire was necessitated by the complete detachment of the rib at the second chondrosternal articulation. Corks were attached to the wires which projected three-quarters of an inch from the skin. The wires were removed in four weeks, and the patient was permitted to leave the hospital for sick furlough four days later.

SURGICAL PRINCIPLES OPPOSED TO "RULE-OF-THUMB" IN THE TREATMENT OF COMPOUND FRACTURES. Clay Ray Murray. *Annals of Surgery*, CXVIII, 305, August 1943.

The author calls attention to the risk to the individual patient, in applying routinely any method of treatment based on statistical analysis of the effects of single factors in treatment. He emphasizes the need of knowing when not to use a procedure which has even a small percentage of failures as a routine result. He discusses the need of evaluating all the varied factors in compound fractures under the following headings:

1. The problems presented by a compound fracture,—preventing the translation of contamination into clinical infection, minimizing of the damage done by infection if it develops, and the healing of damaged tissues as quickly as possible with a minimum of residual tissue disability and deformity.

2. The necessity for regarding the wound and the fracture as parts of the same problem.

3. The necessity for dealing with both of these problems simultaneously at all times.

4. What it is desired to accomplish for the wound and for the fracture by the procedures employed,—the removal of as much contamination and the addition of as little as possible, the removal of as much dead and devitalized tissue with as little additional damage as possible, the elimination of dead spaces within the wound, the closure of the wound as adequately and accurately as possible without tension at the time of closure or subsequent to closure, rest of the wound until the risk of infection has been passed and the healing of the wound has been adequately initiated.

5. The basis for decision as to procedures to be employed in any individual case,—contamination or infection of the wound, circumstances under which the wound was received, the type and severity of the violence, and the adequacy and promptness of first aid, as well as the lapse of time between injury and treatment.

6. The procedures now in common use or advised for common use from the standpoint of the accomplishment of treatment aims,—emergency or first-aid treatment, the employment and character of wound débridement and wound drainage, wound closure (soft parts), and wound closure (bone).

BLUE SCLERAS, BRITTLE BONES AND DEAFNESS: A REPORT OF AN AFFLICTED FAMILY. Jason E. Farber and Aaron E. Margulis. *Archives of Internal Medicine*, LXXI, 658, 1943.

A family of fifty-two members of whom twelve were affected with the blue-sclera syndrome is here reported. There are apparently now over 500 cases of this malady reported in the literature. In the present family, which is of English-Scotch descent, four generations are affected, and the condition has been transmitted from generation to generation equally in both sexes. Blue sclera was present in all, but brittle bones in only seven, and deafness in only four of the latter. Other characteristics of the syndrome are: small stature, hypermobility of the joints, relaxation of the ligaments (subluxations were quite common), and, often, abnormal shape of the head. Roentgenograms showed slender bones and osteoporosis.

A curious characteristic of the family was its universal dislike of milk. One wonders

how etiological this might have been, and how the dietary abnormality might have arisen. Calcium studies in one patient showed no distinct increase of calcium excretion.—*Clark W. Heath, M.D., Cambridge, Massachusetts.*

CLINICAL OBSERVATIONS ON OSTEOPETROSIS AND MYELOFIBROSIS. Nathan Rosenthal and Lowell A. Erf. *Archives of Internal Medicine*, LXXI, 793, 1943.

The authors present one case of osteopetrosis and seventeen cases of myelofibrosis. The cases illustrate the following proposed classification:

1. Osteopetrosis (Albers-Schönberg disease, or marble bones).
2. Myelofibrosis (myelosclerosis, leukoerythroblastic anaemia, osteosclerotic anaemia, non-leukaemic myelosis).
   - A. With refractory anaemia without roentgenographic changes in the osseous system.
   - B. With associated myelaemia
     - (a) Leukopenia or normal white-blood-cell levels without roentgenographic changes of the osseous system.
     - (b) Leukopenia or normal white-blood-cell levels with roentgenographic changes.
     - (c) Leukocythaemia without roentgenographic changes.
     - (d) Leukocythaemia with roentgenographic changes.
   - C. With associated "spent" polycythaemia.
     - (a) Without roentgenographic changes of the osseous system.
     - (b) With roentgenographic changes of the osseous system.

The case of osteopetrosis was in an eighteen-month-old boy who had retarded physical and mental development, progressive enlargement of the spleen and liver, and anaemia. Roentgenograms showed typical and severe density of all the bones, with transverse striations and old fracture sites.

Refractory anaemia associated with fibrosis of the marrow has been an important concern of hematologists in recent years. It seems, however, that knowledge of the condition is too little to warrant describing it as a distinct entity. It appears to occur not only independently, but as late stages of various conditions such as leukaemia and polycythaemia vera. The anaemia is undoubtedly referable to the occupation of the bone marrow by fibrosis. The explanation of the fibrosis is only in the hypothetical stage. It is not unlikely that it will prove to be the result of different kinds of injury to the marrow, and therefore myelofibrosis will become a pathological sign and not necessarily a clinical entity. Among the seventeen cases reported by Rosenthal and Erf there was frequently reported some factor possibly toxic to marrow, such as roentgenotherapy, benzol, or arsphenamine.

The authors should have added to their excellent bibliography the references to Bomford and Rhoads (*Quarterly Journal of Medicine*, X, 175 and 235, 1941). The latter report various cases of refractory anaemia, including myelosclerosis, but exclusive of leukaemia, in a large majority of which there was exposure to benzol or some potentially toxic substance.—*Clark W. Heath, M.D., Cambridge, Massachusetts.*

PHYSICAL THERAPY APPLIED AT HOME FOR ARTHRITIS. A FOLLOW-UP STUDY, WITH A SUPPLEMENTARY SUMMARY OF THE SEDIMENTATION RATE OF ERYTHROCYTES IN TWO HUNDRED AND TWENTY-NINE CASES OF ARTHRITIS. Jerome V. Treusch and Frank H. Krusen. *Archives of Internal Medicine*, LXXII, 231, August 1943.

This paper is an appraisal of some of the results of an organized plan which was developed at the Mayo Clinic for encouraging arthritic patients to carry out simple physical therapeutic measures in the home under the supervision of physicians in their home localities. The physical measures employed were:

1. Thermal treatment, including heat, and cold and contrast baths;

2. Massage and manipulation;
3. Exercise, including general postural training.

References to the detailed methods are given.

In the majority of patients the treatment was carried on in the home for over six months. About 80 per cent. of the patients either were enthusiastic about the help which home physical therapy gave them, or stated that they had received some benefit or relief. The data showed that, in addition to printed instructions, demonstration treatments are more effective in getting the patient to carry out the therapy and to do it well. The beneficial results were about equal in the two groups of rheumatoid arthritis and osteo-arthritis.

This article is simply written and the authors have avoided hypothetical discussions about arthritis. It is encouraging to find improvement in so many cases of what is usually regarded as a progressive disease resistant to treatment. Follow-up studies in arthritis, moreover, have been all too infrequent.

As an almost completely unrelated topic, are discussed the ranges of sedimentation rates of the cases of rheumatoid and osteo-arthritis. The great majority of sedimentation rates in the former are faster than those of the latter.—*Clark W. Heath, M.D., Cambridge, Massachusetts.*

ARTHROGRYPOSIS MULTIPLEX CONGENITA. Miriam Katzeff. *Archives of Surgery*, XLVI, 673, 1943.

Arthrogryposis multiplex congenita means multiple congenital contractures of joints. The author found the disease mentioned in only two textbooks. Eighteen cases were observed in the Children's Hospital in Boston during a period of eighteen years. Histologically, atrophy and replacement of muscle by fat are present. Treatment consists of manipulations, supports, and surgical correction. The results are satisfactory, as illustrated by a typical case history with photographs.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

TREATMENT IN CASES OF SLIPPED CAPITAL FEMORAL EPIPHYSIS AT THE MASSACHUSETTS GENERAL HOSPITAL. Armin Klein, Robert J. Joplin, and John A. Reidy. *Archives of Surgery*, XLVI, 681, 1943.

The authors present an analysis of the results of treatment of thirty-two patients with femoral epiphysiolysis. The results depend on early diagnosis. The treatment recommended is arthrotomy and reposition of the slipped epiphysis by means of a three-flanged nail, followed by traction and wearing of non-weight-bearing splints. Early mobilization, and recognition of incipient slipping on the contralateral side are stressed.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

ADVENTITIOUS BURSAS. John G. Kuhns. *Archives of Surgery*, XLVI, 687, 1943.

This is a complete and scholarly report on adventitious bursae, including their histology, development, pathology, and therapy. Adventitious bursae, rarely lined with endothelium, develop after birth beneath skin and around tendons exposed to pressure and friction. Their development was studied in persons wearing badly fitting shoes and orthopaedic apparatus. The bursa often develops beneath a skin callus, and may later become inflamed, infected, and hemorrhagic, and may contain cartilaginous bodies. It develops from normal subcutaneous connective tissue, which, by growing parallel to the pressure exerted on the skin, and, by flattening out subsequently, forms a cavity filled with a fluid containing a mucin-like substance. The walls gradually grow thicker, and villi develop. The lining may become a true synovial membrane. Tumors, mainly sarcoma and xanthoma, as well as tuberculosis, may involve these bursae. Small bursae recede when the irritating cause disappears. Large bursae usually have to be excised.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

DEVELOPMENT OF THE HUMAN KNEE JOINT. Leo J. McDermott. *Archives of Surgery*, XLVI, 705, 1943.

The author presents a detailed study, with beautiful photomicrographs, of the development of the human knee joint from early foetal life to the age of twelve years. He was particularly interested in the histological origin and developmental chronology of the menisci and synovial membrane. According to the serial sections examined, the joint cavity develops during the eighth week of foetal life from the cartilaginous disc between the cartilages of tibia and femur; the joint cavity is formed by disappearance of parts of this disc, while the menisci, ligaments, and capsule are formed by the remaining parts of the disc. The menisci are fully developed before synovial membrane appears. Synovial membrane is not endothelial, but develops by rearrangement of the cells along the free borders of the menisci and internal surface of the capsule; at no time does it cover the bony articular surfaces. It disappears from the avascular weight-bearing areas of the meniscus at the age of about two and one-half years. The joint space develops first; the menisci, capsule and intra-articular ligaments next; and the synovial membrane and synovial villi last. Assisted by several professors of Harvard Medical School and by members of the Children's Hospital in Boston, the author has given an accurate and thoughtful presentation which should be read by all workers interested in research.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

FRACTURE OF THE NECK OF THE ASTRAGALUS. Francis M. McKeever. *Archives of Surgery*, XLVI, 720, 1943.

The high incidence of aseptic necrosis following fracture of the neck of the astragalus has been known for a long time, but opinions differ with regard to the intrinsic circulation of the astragalus and the method of treatment of this injury. The author reports on his studies of the intrinsic circulation by means of injection of radiopaque media into the tibial arteries of specimens. The results suggest that the main blood supply is through vessels arising from the anterior tibial artery and entering the neck of the astragalus through the superior astragaloscaphoid ligament. (In the experience of the abstractor, the results of studies with radiopaque media have to be considered with reserve, since most of the media used are too viscous to enter the smaller but vitally important vessels.) The author points out that, in confirmation of Phemister's studies, aseptic necrosis often leads to degeneration of the corresponding articular cartilage, with consecutive arthritis. He suggests that surgical erasion of the subastragalar articular cartilage may shorten the period of revascularization of the astragalus, by removing the cartilaginous barrier.—*Albert Oppenheimer, M.D., Laconia, New Hampshire*

SUBTROCHANTERIC OSTEOTOMY IN COXA VARA. Charles W. Peabody. *Archives of Surgery*, XLVI, 743, 1943.

The author describes a technical modification of the Riedel-Schanz operation for coxa vara. The aim of the procedure described is to transform the abnormal adduction into slight abduction. This conversion of coxa vara into coxa valga results in lengthening of the previously shortened limb. The osteotomy wedge is so made that its apex forms a pivot point on which the femur moves as the thigh is abducted; the removed wedge is impacted into the medial cut. The results are good, as illustrated by roentgenograms.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

PARATROOPER FRACTURE. William J. Tobin. *Archives of Surgery*, XLVI, 780, 1943.

Fracture of the posterior inferior margin of the tibia ("posterior lip" of the tibia) occurred alone in 12 per cent. of all fractures observed in parachute jumpers training at Fort Benning, Georgia. In at least another 4 per cent., this fracture was associated with fracture of the internal or external malleolus. As a rule, there was no appreciable dis-

placement of the fragments, possibly because the high boots worn by the jumpers fit so tightly that the fragments are held in place. Consequently, no case required open reduction. Treatment consisted in immobilizing the joint, for an average of four weeks, in a plaster cast with an attached walking iron. The patients were allowed to resume parachute jumping after three months. The mechanics of this fracture are described in some detail. Excellent roentgenograms illustrate the lesions involved. Tobin believes that this fracture occurs frequently enough among parachute troops to justify the introduction of the term "paratrooper fracture".—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

Torsion of the Achilles Tendon: Its Surgical Significance. J. Warren White. *Archives of Surgery*, XLVI, 784, 1943.

Lengthening of the Achilles tendon was the first modern orthopaedic operation, and is still the most common single operation performed by orthopaedic surgeons. White points out that the difficulty encountered during subcutaneous tenotomy of the heel cord lies in the anatomical twist, the Achilles tendon having a 90-degree torsion on its own axis. Tenotomy, therefore, should be so done as to overcome the torsion, so that the tendon will not "hang". This can be achieved by severing the anterior two-thirds of the tendon at a convenient point, and by severing the medial two-thirds two or three inches above this point. The physiological torsion of the Achilles tendon is not described in modern texts, but the author found it to be present in the common domestic mammals. Photographs and drawings illustrate the torsion and the placing of the recommended tenotomy cuts.—*Albert Oppenheimer, M.D., Laconia, New Hampshire.*

Meningocosis del aparato locomotor (Meningocosis of the Locomotor Apparatus). Helmut W. Jaeger. *Archivos de la Sociedad de Cirujanos de Hospital*, XII, 305, 1942.

Thirty-seven cases of meningococcic arthritis were clinically diagnosed among 1000 cases of meningococcic infection (3.7 per cent.). The real frequency of arthritis, however, is higher, for in postmortem examinations of forty cases, nine cases of purulent synovitis were found which had not been clinically diagnosed.

Two new localizations of the meningococcic infection of the locomotor apparatus are described,—purulent bursitis and purulent tendosynovitis.

The term meningocosis is proposed in order to designate the meningococcic infection on the whole from the inflammation of the joints, bursae, and tendon sheaths, which are called meningocosis of the locomotor apparatus.

The anatomicoclinical classification of Herrick and Parkhurst is questioned, as in most cases, the meningococcic arthritis is purulent synovitis, and the so-called "meningococcic arthralgias" are also arthritis.

The most frequently involved joints are the wrist and knee. There is little difference in frequency between mono-articular and polyarticular involvement.

The prognosis is usually good, though it should be remembered that some cases of meningococcic osteo-arthritis reported in the literature, have ended in ankylosis. The sulfonamides have no effect on the course of the disease. In meningococcic osteo-arthritis, as in similar destructive osteo-arthritic lesions, any orthopaedic treatment must be adapted to each individual case.

Metastatic Prostatic Cancer; Its Endocrine Factor. Enrique Lagomarsino. *Boletines y Trabajos de la Sociedad Argentina de Cirugia Ortopédica*, VII, 306, 1942.

A new horizon has been opened on the biology of tumors, especially with regard to prostatic cancer, by the elimination of the androgenetic activity after orchidectomy, and the neutralization of androgenetics with the administration of estrogenics.

The author presents a case of cancer of the prostate with numerous bone metastases,

symptoms of extreme cachexia, root pain with radiation to lower limbs, and with an advanced stage of barbituric intoxication. The immediate result of orchidectomy in this case was especially good. After two years of illness and one year of intense pain which did not react to radiotherapy and morphine, orchidectomy relieved the pain within forty-eight hours. Three days later the patient refused barbiturates, and fifteen days later he started walking. It is now thirty-two days since the operation. The general condition of the patient is good; he has gained six kilograms in weight. This proved to be a case of adenocarcinoma of the prostate. The testicle weighed twenty grams.—*H. de Goes, M.D., Iowa City, Iowa.*

Osteogenesis Imperfecta. J. F. Brailsford. *British Journal of Radiology*, XVI, 129, May 1943.

According to Brailsford, who is the author of a well-known textbook on radiology of the bones and joints, osteogenesis imperfecta is the same disease as osteopsathyrosis or fragilitas ossium. Many other bone lesions, however, may be associated with imperfect ossification. Osteogenesis imperfecta is a familial disease, and is associated with blue sclera, and sometimes with deafness perhaps caused by osteosclerosis. Brailsford adds that blue sclera may occur without imperfect ossification, and imperfect ossification without blue sclera, and that osteogenesis imperfecta need not be familial. He states, "from the radiographic evidence it is possible to anticipate the histologic structure". This statement is not supported by histological studies. He believes that the roentgenographic features of osteogenesis imperfecta are: in infancy, failure of ossification to pass beyond the stage of calcification; during puberty, irregular metaphyseal growth and other secondary changes; in the adolescent and adult, thinning of the skull, deformities of the ribs, and bending of the pelvic bones and femora due to increased plasticity. No proof is submitted for these assumptions.

The Osteogenic Graft in Tuberculosis of the Hip-Joint in Childhood. E. D. Telford and J. E. Geddes, *The British Journal of Surgery*, XXX, 189, January 1943.

The osteogenetic graft, unlike the fixative graft, is inserted into the diseased joint, but must be used only when the disease is quiescent. It is used to stimulate osteogenesis by the action of fresh osteoblasts on granulation tissue which is stagnant and unable to form bone.

The graft is taken from the trochanter and the adjacent part of the femoral shaft, and is two and one-half to three inches long and one-third to one-half inch wide. The periosteum is removed, and the graft is cut with an osteotome or electric saw. The incision is made in the line of the femur with the trochanter in the center of the incision. The upper edge of the acetabulum is identified, and a gouge is inserted into the diseased joint, making a groove in the softened bone. The graft, fully detached, is pushed into this groove, the femoral end first. The other end fits into the slot in the trochanter. The joint is closed without drainage.

Bony union, was obtained in nineteen of twenty-six cases in which this operation was used. In seven, firm fusion was not obtained.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Traction Injuries to the Lateral Popliteal Nerve and Traction Injuries to Peripheral Nerves after Suture. W. Bremner Highet and W. Holmes. *The British Journal of Surgery*, XXX, 212, January 1943.

The writers present eight cases of traction injury to the lateral popliteal nerve, and refer to nine others reported by Platt. This injury follows a severe adduction strain of the knee, by which the lateral collateral ligament is ruptured, and a subluxation or dislocation is produced. The results of the repair of these injured nerves have been studied,

together with the segments of nerves removed. Material is presented on the results of suture of other nerves. It is apparent that failure of the nerve to regenerate after operation may be due to further traction injury at or following the operation.

The traction lesion is characterized by more damage to the nerve trunk than is found after injury by incision, laceration, or gun-shot wound. Pathological changes extend far above the point of apparent injury, and consist of fiber degeneration, intraneural fibrosis, and vascular abnormality. The connective-tissue sheath of the nerve may rupture to a varying degree; there may be complete rupture of the nerve, or there may be an apparently intact nerve with a large fusiform neuroma present.

In several cases where failure had occurred, a second operation showed that changes in the remaining nerve were similar to those found at the first operation.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Slow Union of Fractures. With a Study of 804 Fractures of the Shafts of the Tibia and Femur. R. Watson-Jones and W. D. Coltart. *The British Journal of Surgery*, XXX, 260, January 1943.

From their study of a large series of fractures of the shafts of the tibia and femur, treated in Orthopaedic Centers of the Royal Air Force Medical Service and the Liverpool Royal Infirmary, the authors reach the following conclusions:

1. In spite of rumors to the contrary "uncomplicated fractures treated by simple manipulation and plaster are uniting as quickly today as in former years".

2. Ten to twelve weeks is the minimal period of immobilization of fractures of the shaft of the lower limb. Uncomplicated fractures unite in about twelve weeks, difficult fractures in twelve to twenty-four weeks, infected and distracted fractures in six to twelve months, and avascular fractures in one to three years.

3. Interrupted immobilization, traction and distraction, infection, persistent angulation, too early weight-bearing, and loss of blood supply cause delayed union. If the period of immobilization is prolonged accordingly, non-union does not occur. "Every fracture unites if it is immobilized long enough."

4. Skeletal traction accounts for the increasing number of cases of slow union, particularly in fractures of the shaft of the tibia.

5. Operative reduction does not cause delay. Internal fixation is recommended rather than traction, and it should be applied within the first day or two.

6. Early weight-bearing in plaster, or in skeletal-transfixion apparatus, or in a caliper splint delays union rather than accelerates it. Weight-bearing before the stage of clinical union is unwise.

7. Fractures of the shaft of the femur should be reduced by early manipulation rather than by heavy traction.

8. Infection of fractures and soft parts causes delay in union. It should be treated by early wound excision, early sequestrectomy, and early skin-grafting. Infection should not be a cause of non-union.

This article closes with a series of tables by Coltart, reviewing studies of 804 fractures of the tibia and femur. In fractures of the tibia and fibula, figures are given for the time of union under various conditions. The percentage of union at various time intervals is stated. In open fractures, union occurred within six months in 34.6 per cent. if infected; and in 61.8 per cent. if not infected. In closed fractures, 31.3 per cent. united within six months, if there was distraction; 74.1 per cent., if there was interrupted immobilization; and in 95.4 per cent. if there was continuous immobilization. However, in the latter group 41.7 per cent. were united within three months.

In fractures of the femoral shaft, union occurred within six months in 47.8 per cent. of the open fractures; in 92.9 per cent. where there was distraction; in 64.3 per cent. where open reduction had been performed; and in 94.7 per cent. in uncomplicated cases.

Other tables in this article are well worth studying.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

CONGENITAL DISLOCATION OF THE HIP. Harry Platt. *The British Journal of Surgery*, XXX, 291, April 1943.

Congenital dislocations of the hip are uncommon among Anglo-Saxons, but are frequent in southern France, Poland, and Czechoslovakia, and most common among Italians. Vittorio Putti, a brilliant Italian orthopaedic surgeon, by his writings and teachings, contributed much to the knowledge concerning treatment.

Lorenz, a Viennese orthopaedic surgeon, was among the first to advocate reduction by manipulation,—the "bloodless method". He treated nearly all cases in the same way, and used great physical force. It has now been proved that gentleness is imperative, that manipulation should not be used after the patient is four years of age, or where anatomical obstacles prevent reposition of the head of the femur.

The author has reviewed fifty patients, with sixty-two manipulated hips, and finds at the end of ten years that forty-six joints show excellent function, but only twenty-nine show good anatomical results. The causes of failure may be due to congenital anomalies of the capsule or acetabulum. Residual subluxations may occur after apparent satisfactory reduction.

Open operation is indicated in certain children under four, where it is apparent that manipulation would not succeed, in older children, and for residual subluxations.

In infants under one year, gradual abduction by the use of the *divaricator* (the method first described by Putti in 1927) is recommended.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

SCIATICA AND THE MECHANISM OF THE PRODUCTION OF THE CLINICAL SYNDROME IN PROTRUSIONS OF THE LUMBAR INTERVERTEBRAL DISCS. John E. A. O'Connell. *The British Journal of Surgery*, XXX, 315, April 1943.

If spinal tumor, tuberculosis, metastatic malignancy of the spine, and malignancy of the pelvis can be excluded, the usual cause of sciatica is protrusion of a lumbar intervertebral disc into the spinal canal.

Usually a clinical diagnosis can be made without the injection of opaque substances or air followed by roentgenographic examination. In this article, only the discs between the fourth and fifth lumbar, and the fifth lumbar and the sacrum are considered.

The distribution and type of pain are fairly constant. The pain commences in the lumbosacral region, passes across the buttock, and passes down the posterior aspect of the thigh to the popliteal space. It usually spreads down the outer side of the calf into the foot. The pain at times is stabbing, or it may be a dull ache. Usually any form of exercise increases the pain. There are usually remissions from pain for varying periods of time. In the area where pain is felt there are often sensations of pins and needles, tingling, or numbness. In half of the cases there is a history of trauma before the onset of symptoms.

On physical examination great stress is laid on Lasègue's sign, a modification of straight-leg raising. After straight-leg raising has been attempted, and the point at which pain has been experienced is noted, both legs are raised. The angle of flexion permitted will be greater than when the affected limb alone is raised, or possibly greater than when the normal limb is raised.

"The pathogenesis of the syndrome is considered and the hypothesis is put forward that the usual type of lumbar disc protrusion causes symptoms and signs of nervous disturbance by stretching the related intraspinal extradural nerve. The evidence for this hypothesis is discussed, and is based on embryological, morphological, and clinical considerations."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE USE OF IRRIGATION ENVELOPES IN THE TREATMENT OF LACERATED WOUNDS AND COMPOUND FRACTURES. G. K. McKee. *The British Journal of Surgery*, XXX, 328, April 1943.

The lacerated wound is cleaned up and all devitalized tissue is removed. The wound is cleansed with a 1 to 5 dilution of 1-per-cent.-solution of electrolytic sodium hypochlo-

rite. An occlusive silk envelope with inlet and outlet valves is applied. Irrigation of the wound with a 1 to 20 dilution of the same solution is carried out three times a day.

A report is given on thirty-two cases. It is claimed that this is a simple method of dealing with dirty wounds, and that sepsis can be controlled, so that active movements can be instituted at once. It is said to be excellent for compound wounds, but cannot be combined with plating fixation. Skeletal pins are recommended.

The patients treated by this method did well, and they were comparatively free from pain or other reaction.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE EFFECTS OF STRETCHING NERVES AFTER SUTURE. W. B. Highet and F. K. Sanders. *The British Journal of Surgery*, XXX, 355, April 1943.

This paper on experimental stretching of nerves is a corollary to the clinical paper by Highet and Holmes appearing in the January number of the same journal.

Extensive resection of the popliteal nerve of dogs was carried out with suture of the nerve; the knee was kept in flexion for fourteen days. Gradual or rapid stretching of the nerve was then performed and the results were noted. Stretching occurred mostly near the extremities of the severed nerve. Rapid stretching caused no more damage than gradual stretching.

The following histological changes were noted:

1. Extensive degeneration of the central stump.
2. Separation of the stumps.
3. Rupture of Schwann tubes in the region where stretching was most severe.
4. Oedema and fibrosis within and without nerve bundles.

The bearing of these results on the postoperative stretching of human nerves is discussed.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

EXPERIMENTAL STUDY ON NERVE SUTURE WITH VARIOUS SUTURE MATERIALS. Ludwig Guttmann. *The British Journal of Surgery*, XXX, 370, April 1943.

Studies were carried out on the tibial nerves of rabbits, and various types of suture material were used for suture of the cut nerves.

Plain catgut, plain white silk, unwaxed black and green silk, waxed black silk, and woman's hair were used in groups of cases.

Each of these materials, if used as a through-and-through suture, caused undesirable cellular and fibrous reactions and obstacles for the regenerating axons. Woman's hair and plain white silk were the least irritating materials used. Epineural suture is recommended.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

CONGENITAL DISLOCATION OF THE HEAD OF THE RADIUS. James R. A. White. *The British Journal of Surgery*, XXX, 377, April 1943.

This is a case report of a female, fifty years of age, who was seen following an injury. An anterior dislocation of the head of the radius without fracture of the ulna was detected by roentgenographic examination. The radius was longer than normal, and the dome-shaped head had no articular surface for the capitulum of the humerus.

On fluoroscopic examination, in flexion the head of the radius slid over the anterior surface of the humerus, while in extension the head lay dislocated over the anterior surface of the capitulum.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

DISLOCATION OF THE CARPAL SCAPHOID REDUCED BY OPEN OPERATION. G. B. Woodd Walker. *The British Journal of Surgery*, XXX, 380, April 1943.

This is a case report of a male of forty-four years, who, while cranking a motor, had been injured by a back-fire. However, at the time of the back-fire, his thumb had been along the side of the index finger and not in apposition to it.

Closed manipulation failed, and an open operation was done. The scaphoid was found to be rotated through 180 degrees. It was necessary to remove it, after which it was replaced without fixation. Recovery has been satisfactory.

Comment is made on the rarity of this type of dislocation. The mechanism is not clear, but several possibilities are mentioned.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

NERVE REGENERATION. (Editorial.) *British Medical Journal*, I, 606, 1943.

In addition to its intrinsic interest, the subject of nerve regeneration becomes increasingly important in time of war. There is an extensive literature on the subject, as many as 928 papers being collected by Rossia and Gestaldi up to 1934. Most of these lay emphasis on regeneration from the point of view of histology or function, but few studies have combined the two. In a recent review, Young has pointed out that the functional recovery of a regenerated nerve becomes complete only when the fibers are of a certain diameter and state of medulation, and can carry impulses of appropriate frequency and velocity. Holmes and Young conclude that the process of the union of stumps and the regeneration of a new functionally efficient stretch of nerve are less satisfactory after the longer period of degeneration. Postponement of suture for one or two months does not prejudice the chances of recovery and may even improve them. Longer delays, especially those greater than six months, bring about conditions which are likely at least to retard recovery and may permanently prevent it.

Weddell finds that nerve fibers first advance along the original main nerve fasciculi. The first fasciculi to be reinnervated are those lying in closest proximity to normal nerve trunks. He has also found that cutaneous nerve bundles close to the larger blood vessels are more rapidly reinnervated than those farther away.

The more rapid regeneration of nerve fibers along blood vessels is also in accord with the observations of Trotter and Davies, who observed that vasomotor control returned more rapidly than skin sensation.

The more rapid regeneration of cutaneous nerve fibers in the neighborhood of blood vessels may serve to explain the bridges of cutaneous sensibility which, in man, are commonly found to cross an area of sensory loss during the course of regeneration from the proximal stump of the divided nerve.

After complete division of a nerve, early suture is important. In cases of incomplete division, or neurapraxia (Seddon), a most careful assessment of the damage done is essential before operative intervention is decided upon. To this end Guttmann has shown the value of the thermoregulatory sweating test, which gives a clear indication of the amount of autonomic damage in the cutaneous nerve. More recently Weddell, Feinstein, and Pattle have shown that an accurate assessment of the injury to a peripheral nerve supplying a voluntary muscle can be made by electromyography. It is to be hoped that, by combining these two procedures with a clinical examination, the treatment and prognosis of peripheral nerve injuries will advance considerably.

It seems probable that axons within the central nervous system do not regenerate, once they are mature. It is also clear that the explanation for this is not to be sought in the absence of Schwann cells in the central nervous system, but in other factors. Tower has lately shown that the anterior-horn cells in the spinal cord, when avulsed, can send out new axons along paths devoid of Schwann cells. There seems to be some factor related to all peripheral nerves which is absent in the intrinsic neurons of the central nervous system.

TREATMENT OF THE FRACTURED GREAT TOE. G. N. Taylor. *British Medical Journal*, I, 724, 1943.

Fracture of the great toe is the commonest fracture in injury, and, though considered of minor significance in traumatic work, it may be followed by days and even weeks of disability. Griffiths' method of treatment has reduced the period of disability from an average of eighteen weeks to a period often less than ten days.

The tension and pain caused by the subungual hematoma is relieved by trephining the nail, the opening, no more than two millimeters in diameter, being placed over the most prominent part of the hematoma. A plaster-of-Paris thimble, put on over vaseline gauze and enclosing the whole toe, provides adequate immobilization.

When the proximal phalanx is fractured, a plaster toe splint, made to enclose the sides and plantar surface of the toe, extends along the medial surface of the foot to the tubercle of the navicular and across approximately half of the sole. The limb is then elevated for about forty-eight hours. On the third day, the patient is allowed to walk in a heavy working shoe about two sizes larger than usual. The larger cast can usually be replaced by the thimble at this time.

In compound fractures, conservation of tissue is the aim. If amputation is necessary, preservation of the metatarsophalangeal joint must always be the goal. Where possible a small portion of the proximal phalanx should be left—instead of disarticulating the toe—so as to maintain the integrity of this most important joint. It is hardly necessary to state that the head of the first metatarsal must be preserved at all costs, because it, together with the remaining metatarsals and the os calcis, forms the tripod on which the weight of the body is borne.

PRINCIPLES OF EXERCISE THERAPY. Ernest A. Nicoll. *British Medical Journal*, I, 747, 1943.

This very excellent article is written to give a working understanding of the proper usage of therapeutic exercise in the rehabilitation of bone and joint injuries. The author, in directing the work of an accident service which deals with fractures and injuries of the locomotor system, has applied the principles of the Ling system of gymnastics in the treatment of his patients, and gives the reader a concise and comprehensive description of this time-proved system. He stresses the importance and value of properly selected exercises. Subheadings include Focal and General Exercise, Dosage, Rhythm, Progression, and Variation. Two illustrations of the use of pulleys in increasing shoulder and knee-joint function add to clear directions for their use. The time spent in careful study of this article will be of benefit both to the surgeon for whom it was written and to the physiotherapist within whose province falls the detailed application and elaboration of these principles.—*Lucy G. Marshall, Boston, Massachusetts.*

PLANTAR DISLOCATION OF THE FOURTH METATARSAL. George B. Mair. *British Medical Journal*, II, 169, August 7, 1943.

Dorsal dislocation of the head of a metatarsal bone is not infrequently encountered in orthopaedic and surgical practice, but plantar dislocation appears to be almost unique. The following case is reported:

A soldier, aged twenty-eight, was admitted to hospital complaining of pain and swelling in the sole of the foot, which was aggravated by walking. He had been at a dance four days previously, wearing light-weight patent-leather shoes, and had "slithered down two stairs", landing on the "ball of his foot". He felt a sudden sharp pain, but was able to walk without much inconvenience for the rest of the evening, and he reported for duty as usual the next day. During that afternoon he had begun to complain of a dull pain in the sole of the foot, which had become somewhat swollen. On the following morning, he reported to his Medical Officer who considered that he had a sprained ankle. Two days later he was admitted to hospital.

On examination, no abnormality was detected other than the local condition in the foot. The foot showed a moderate degree of swelling, and on the bases of the four small toes on their dorsal aspect there was slight bruising, mostly on the outer side. A space was palpable over the head of the fourth metatarsal bone, and the third and fifth toes were slightly crowded together, overlapping the fourth. Movement of the toes was

quite free. On the sole of the foot was a definite swelling, hard, smooth, regular, fixed, round, localized, and tender. It was diagnosed as the head of the fourth metatarsal dislocated plantarward. The dislocation was reduced by open operation, as it was irreducible by manipulation. The postoperative course was uneventful, and the patient was discharged to a convalescent depot in four weeks.

The mechanism of this injury is hard to explain. The patient was not helpful in describing exactly what happened, but it was established that he had slipped down two steps and abruptly landed on the ball of the affected foot. He considers that his toes were fully "cocked up" at the time, and that he leaned forward to recover his balance. It may be possible that full dorsiflexion of the toes accompanied by violent forward swinging of the body on the fixed foot may slip the head of the metatarsal out of position, but this is improbable, and the explanation is unconvincing.

KIENBÖCK'S DISEASE: AETIOLOGY. M. E. Gordon. *British Medical Journal*, II, 200, August 14, 1943.

Most authors agree that the condition in Kienböck's disease is fundamentally an avascular necrosis, but there is a divergence of opinion concerning the etiology. In discussing the origin of this disease the author states that, although bacterial infection or trauma are factors to be considered, hematogenous infection is most probable. If the nutrient arteries entering the lunate bone via the anterior and posterior ligaments are both ruptured, avascular necrosis must follow. Rupture of one is not usually sufficient to interfere with adequate nutrition.

The author reports two cases and, from his experience with these, he emphasizes the importance of roentgenographic examination in all cases of injury and disability of the wrist, with follow-up x-rays in all cases that do not respond to treatment.

AETIOLOGY OF THE FIBROSITIC NODULE: A CLINICAL CONTRIBUTION. W. S. C. Copeman. *British Medical Journal*, II, 263, August 28, 1943.

As the result of a study of forty patients with influenza, none of whom had had rheumatism previously, the author believes that a rheumatic nodule which can be palpated is a sign of chronicity of the complaint, and that a "myalgic spot" is probably an earlier stage of what later may become a nodule if not treated.

A prominent feature of this epidemic was lumbar and other pain, which was referred from small hypersensitive areas in the muscles. These were indistinguishable from "rheumatic" myalgic spots. On examination one or two months later, these spots, in diminishing numbers, were still present in about half the patients. The patients, however, were unaware of them until pressure from the examining finger disclosed them.

Myalgic spots, which had arisen spontaneously during the influenza, were reactivated in one patient by mumps three weeks later, and in another by the artificial induction (with permission) of sandfly fever by the inoculation of infected blood two weeks later. In a third case there was evidence suggesting that the common cold might maintain the activity of the myalgic spots.

Rheumatic pains are a characteristic sequel of many of the exanthemata, mostly those of virus origin. Observation has shown that these pains, which tend to arise in a less acute manner, are also generally of the focal type.

The author suggests that myalgic spots which form the basis of many of the rheumatic syndromes of later life, are sometimes a legacy from acute infections in earlier years. It is important to remember that the victims are often unaware of the presence of the myalgic spots until they become activated by such factors as chill, trauma, or focal sepsis. These factors should consequently be regarded as secondary and not as causative in such cases.

TRAUMATIC TRANSVERSE SCARRING OF THE TIBIALIS ANTICUS MUSCLE WITH FUNCTIONAL BLOCK. Harold H. Cohen. *Bulletin of the Hospital for Joint Diseases*, III, 109, 1942.

The author first calls attention to Hipps' article of February 1941, in which he described the transverse areas of degeneration in poliomyelitic muscles with functional ratings of poor to zero. He then describes his case of a male, forty years old, who had sustained severe, soft-tissue trauma to the right leg. Three months later, examination revealed two scars on the right leg, one over the inner aspect of the upper third, the other over the outer aspect of the tibialis anterior at a lower level. Neither was adherent to underlying tissues. On standing, the tibialis anterior tendon was not visible on the right, but was visible on the left,—the sound side. Distal to the scar, over the tendo achillis, the tibialis anterior was flabby and bulging. Dorsiflexion was present to 90 degrees, but inversion was limited and carried out by the extensor hallucis longus and the tibialis posterior. Palpation failed to elicit any contraction of the muscle adjacent to the anterior crest of the tibia. Faradic stimulation did not cause any visible or palpable contraction. The diagnosis rested between rupture of the muscle at its musculotendinous junction and a crush injury. Surgery was performed, and the musculotendinous junction was found intact, but in the central portion of the muscle belly a nodular mass comprising the entire depth of the muscle belly was felt, and running longitudinally down the center of the entire muscle was a narrow white tendinous strip of fibrous tissue. All the pathological tissue was removed, and the muscle was repaired with mattress sutures. Upon faradic stimulation, proximally, muscle and tendon contracted. This, however, had not been tried before excision was done. Microscopically the excised tissue showed muscle fiber replacement by acellular, fibrous connective tissue. After three weeks, voluntary active inversion and dorsiflexion were noted, pain and tenderness were gone, and faradic stimulation elicited definite response. At the end of three months there was complete return of function.—*N. Kaplan, M.D., Iowa City, Iowa.*

NERVES OF THE ARM: SOME OF THEIR AFFECTIONS; THEIR DIAGNOSIS. Robert Wartenberg. *California and Western Medicine*, LIX, 22, July 1943.

Neuritis of the whole or part of the brachial plexus and ulnar and median nerves may appear in convalescence from general infections, or from the trauma of contusions or severe stretching. The frequently found cervical spondylarthritis in adults is rarely the cause of neurological findings. Paraesthesias of the arm and hand during sleep is, of itself, a self-limited clinical entity.

The "newspaper sign" of Froment may be used to test the functions of both the ulnar and median nerves,—the short adductors being innervated by the ulna, while the long flexor is innervated by the median nerve. Ulnar palsy is further indicated by persistent abduction of the little finger, because the extensor minimi digiti is innervated by the radial nerve. The abduction of the thumb is an exclusive function of the median nerve, and a test for this special motion indicates the condition of this nerve. This must be distinguished from "partial thenar atrophy", which is characterized by atrophy of the lateral muscles, the opponens pollicis, and the abductor pollicis brevis, which are also supplied by the median nerve.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

SUBLUXATION OF THE ANKLE. G. F. Pennal. *The Canadian Medical Association Journal*, XLIX, 92, January 1943.

The author reports fourteen cases of subluxation of the ankle studied at Camp Borden Military Hospital.

The external lateral ligament is weakened by division into three bands; and in a severe inversion, external rotation strains may result in a complete tear of the anterior and middle fasciculi of the outer ligament with momentary subluxation of the talus, unaccompanied by fracture. Swelling and ecchymosis over the outer side of the joint sug-

gests the injury, and if gentle rocking of the ankle in inversion shows that the talus tilts and leaves the mortice of the joint, it appears to be diagnostic of subluxation.

For a good result in treatment, the author advises prolonged fixation for a period of ten weeks in a walking plaster cast, with attached rubber heel in place of a walking iron.

If surgical treatment is required, he recommends the Watson-Jones operation, a combined tenodesis and ligament reconstruction, using the tendon of the peroneus brevis.

WIRE SUTURING IN THE TREATMENT OF FACIAL FRACTURES. Stuart D. Gordon. *The Canadian Medical Association Journal*, XLVIII, 406, May 1943.

The author has found stainless-steel wire sutures invaluable in the repair of malar, maxillary, and mandibular fractures. Infection occurred in only one case and that was received in rather dirty condition. The importance of preventing movement at the fracture line after introduction of a foreign body is stressed. Excellent reductions were obtained by this method and prognosis has remained excellent.

RUPTURE OF COLD ABSCESSES INTO THE LUNGS AND PLEURAE. Oscar Auerbach. *Clinics*, I, 600, 1942.

The author performed an autopsy in ninety-five cases of tuberculosis of the thoracic vertebrae or ribs. The vertebrae alone were involved in sixty-four cases, the ribs alone in thirteen, and both vertebrae and ribs in eighteen. In eighteen of the ninety-five instances (18.9 per cent.) a cold abscess, secondary to tuberculosis of the vertebrae or ribs, extended into the surrounding tissue, fifteen times rupturing into the lung parenchyma and three times into the pleural cavity.

Ten of the perforations into the lung parenchyma occurred in the lower lobe, four in the upper lobe, and one in both upper and lower lobes. This is compatible with the much greater incidence of tuberculosis in the lower thoracic segments.

Eight of the perforations were the result of subperiosteal abscesses secondary to tuberculosis of the rib; two, of the extension of abscesses in the region of the small processes of the vertebrae; and eight were the result of paravertebral abscesses.

Fifteen, or 83.3 per cent. of the patients were Negroes.

The perforation of the cold abscess is caused by the blocking of the paths which the abscess might take. This is brought about by the perifocal reaction produced by a cold abscess as it develops. The pleura and endothoracic tissue in this localized area become thickened and adherent.

Clinical and pathological correlation is possible only in the cases in which the abscess perforates into the lung parenchyma. The main features are:

1. Sudden onset of cough and expectoration of copious amounts of sputum.
2. The sputum, which never contained acid-fast organisms before, now contains tubercle bacilli.
3. The pulmonary lesion develops at the site of the bone pathology, which is most often an atypical location (ten of fifteen cases of rupture into the lung parenchyma occurring in the lower lobe).

TREATMENT OF OSTEOCLASTOMA. James F. Brailsford. *The Lancet*, I, 776, 1943.

The author reports five cases of osteoclastoma (giant-cell tumor or sarcoma), three of which were treated by surgery and biopsy followed by amputation, and two of which were treated by irradiation. It is pointed out that the roentgenographic change is typical, that there is no call for biopsy, and it is the author's opinion that the treatment of choice for osteoclastoma, whatever the site, is irradiation. He points out that irradiation therapy results in an extension of the osteolytic absorption of the involved bone, and states that all bony trabeculae of the tumor area may be wiped out, and that the cortical

and subarticular bony capsule may appear to have been completely destroyed and the adjacent walls still further invaded. He states that these changes are to be expected, but are followed by reossification and ultimate consolidation.—*Lenox D. Baker, M.D., Durham, North Carolina.*

THE SYNDROME OF UNILATERAL RUPTURE OF THE SIXTH CERVICAL INTERVERTEBRAL DISK. WITH COMPRESSION OF THE SEVENTH CERVICAL NERVE ROOT. A REPORT OF FOUR CASES WITH SYMPTOMS SIMULATING CORONARY DISEASE. R. Eustace Semmes and Francis Murphey. *The Journal of the American Medical Association*, CXXI, 1209, 1943.

The authors state that most cases of rupture of the cervical disc described in the literature produce either bilateral or unilateral cord compression, rather than nerve-root compression. They present four cases in which the etiology was a true root compression in the region of the sixth disc, with compression of the seventh cervical root.

Such a syndrome has often been confused with coronary thrombosis, angina pectoris, arthritis of the cervical spine, brachial-plexus neuritis and neuralgia, bursitis, scalenus anterior syndrome, cervical rib, or discogenetic disease.

A unilateral rupture of the sixth cervical disc causes as definite a syndrome as that of rupture of the fourth and fifth lumbar. Diagnosis was made solely on the basis of history and clinical findings. The pain in each case radiated to three general regions: the precordium, a point just medial to the upper end of the scapula, and down the lateral and medial surfaces of the arm.

In each case the patient had considerable difficulty in breathing, and had a feeling of impending death. At the beginning of an attack, the precordial pain was intense, giving every indication of a heart attack. In a few days or weeks this pain abated and arm pain became more definite. All pain was intensified by moving the neck, sneezing, coughing, and straining. Three of the patients complained of definite numbness and weakness of the index finger and slight numbness of the middle finger. Reflexes were normal and there was no muscle atrophy.

Examination showed spasm of the neck muscles. The neck was held rigidly, and abduction of the neck away from the side of the lesion caused increased pain; straight traction brought some relief. In each patient there was an exquisitely tender spot posterior to the scalenus anterior over the exit of the seventh cervical nerve. Three patients had hypaesthesia and hypalgesia over the index finger. Lumbar punctures were done, and the spinal fluids were found to be normal.

A small portion of the lamina was removed under local anaesthesia, and the ruptured disc was found in three of the patients. Two patients obtained complete relief and one obtained some relief, but the arm pain and precordial pain remained. The fourth patient who was not operated upon has occasional attacks of the complete syndrome.—*T. J. Greteman, M.D., Iowa City, Iowa.*

HALLUX VALGUS. Paul Bernard Roth. *The Medical Press and Circular*, CCX, 13, 1943.

The author treats hallux valgus, when the deformity is only slight, by having the patient wear shoes the shape of his foot, usually made to measure, but when the deformity is marked, and certainly when there is overriding of the toes, he advocates excision of the head of the metatarsal.

A tourniquet just above the ankle may be used or not, as desired. After preliminary subcutaneous tenotomy of the common extensors of all the toes, the foot is placed on its outer side, and a horizontal incision, two inches long, parallel with the length of the toe, is made through the bunion. The neck of the metatarsal is cleared of periosteum, and is cut with bone-cutting forceps as close to the head as possible. The skin edges are sutured with continuous silkworm gut, and a gauze pad is inserted between the first and

second toes. When the patient is returned to the ward, the foot of the bed is raised six inches, and a cradle is placed over his foot. On the second day strips of elastoplast, one inch wide, are applied to the dorsal and plantar aspects of the big toe, and their ends are carried up and fixed firmly to the top of the cradle. This is most important, as these act to pull the toe straight, and to make sure there is a space between the base of the phalanx and the cut end of the metatarsal shaft so that hallux rigidus will not develop. The strips are detached from the cradle at night and fixed again in the morning for ten days. When the wound has healed and all tenderness has gone, the patient is fitted with a shoe with a stout sole. A valgus pad of leather and rubber is usually worn for six months. The patient can return to work in six to eight weeks.

The bunion is purposely left intact, to continue as a protection. If it is excised, there is a danger that the scar will adhere to the bone. The sesamoid bones are never interfered with. When healing has taken place, the cut end of the metatarsal will rest upon them.

MANIPULATION IN RHEUMATISM. Guy Beauchamp. *The Medical Press and Circular*, CCX, 233, 1943.

The author urges the use of manipulation to increase the mobility of joints, to remove thickening and tension in the dependent soft tissues, to restore normal circulation by increased movement, and to remove pressure on painful nerves. The cooperation of the patient is essential, because manipulation not followed by movement is useless. The patient must exercise the manipulated joint to obtain any benefit.

Manipulation is particularly indicated in the treatment of residual stiffness and its sequelae due to fibrositis, minor degrees of scoliosis and vertebral misalignment, extension deformities, strong adhesions, rheumatoid arthritis to loosen stiffened joints and flexion deformities, and infective arthritis or ankylosing spondylitis to increase movement.

The author discusses techniques for manipulation of the spine, thoracic vertebrae, and low back. The joint being mobilized must be put into its fullest movement in the direction in which the thrust is to be made, thus eliminating much of the resistance of the patient and sparing him muscle strain and after-pain. In all spinal manipulations, less muscle strain results if the unaffected side is moved first, followed by movement of the affected part.

ANTHROPOMETRY AND ARTHRITIS. I. DIFFERENCES BETWEEN RHEUMATOID AND DEGENERATIVE JOINT DISEASE: MALES. II. DIFFERENCES BETWEEN RHEUMATOID AND DEGENERATIVE JOINT DISEASE: FEMALES. Carl C. Seltzer. *Medicine*, XXII, 163 and 189, 1943.

Based on a study of 400 patients treated at the Robert Breck Brigham Hospital, the author reports the results of an anthropometric comparison between rheumatoid arthritis and degenerative joint disease in both males and females. According to the author's findings, both rheumatoid arthritics and patients with degenerative joint disease are more prevalent among Irish, and English and Scotch groups with a particularly low occurrence among those of Scandinavian origin. The patients with rheumatoid arthritis are younger than those with degenerative joint disease, the mean age for the former being 37.3 years, compared to 56.5 years for the latter. In order to make comparisons more equal, the author selected the twelve oldest in the rheumatoid arthritis group and the twelve youngest in the degenerative joint disease group, the average age for the rheumatoid arthritics being 46.8 years and for the degenerative joint disease group 49.4 years. The patients with rheumatoid arthritis are considerably lighter in body weight with an average of 144 pounds as compared with 180 pounds for the patients with degenerative joint disease.

Anthropometric measurements and proportions also show great differences. Rheumatoid arthritics have shorter arm spans than patients with degenerative joint disease in

absolute dimensions and relative to the total body height, the mean difference being 3.73 centimeters. There are no appreciable differences in other measurements and proportions, such as stature, sitting height, trunk height and their concomitant indices. Rheumatoid arthritics are narrower in the shoulders, have narrower chests, smaller interpapillary diameters, much shallower chests, and remarkably smaller chest circumferences than patients with degenerative joint disease. Another outstanding difference appears in the intercostal angle (costophrenic angle), the mean for the rheumatoid arthritics being 37.22 degrees against 50.28 degrees for the patients with degenerative joint disease. The rheumatoid arthritics have narrower shoulders relative to trunk height, narrower chests relative to stature, smaller chest circumferences relative to stature, and longer sternal lengths relative to chest breadth. They are somewhat narrower in the breadth across the hips, markedly smaller in abdominal circumference, a little narrower in the hips relative to stature, markedly broader in the hips relative to the chest breadth, and narrower in the hips relative to the trunk height. They are also smaller than the degenerative group in distal humeral breadth, narrower in breadth of wrists, smaller in hand length and breadth, and shorter in length of forearm. Their calf circumference is smaller, and there are differences in the relative proportions of the lower extremity dimensions to the other parts of the body. In head, face, and neck measurements and proportions, those of the patients with degenerative joint disease continue to be larger than those with rheumatoid arthritis.

The author has used a modified Kretschmerian system to classify patients with arthritis into types, whereby the individual is rated for three components: pyknic,—the element of softness and roundness; somatic,—the amount of bone and muscle development; and leptic,—the element of linearity and fragility. He describes the degenerative group as being on the whole medium in the pyknic component, very high in the somatic, and distinctly submedium in the leptic. The rheumatoid arthritics are submedium in the pyknic element, and medium in the somatic and leptic components.

The form and extent of these differentiations between the two male groups closely parallel those of the females.

The author stresses the fact that the patient with degenerative joint disease is a strongly lateral, pyknic, big-boned, big-muscled, top-heavy, tapering type of individual as opposed to the *more linear* rheumatoid arthritic.

Case Records of the Massachusetts General Hospital (Case 29251). *The New England Journal of Medicine*, CCXXVIII, 831, 1943.

A thin, pale, undernourished, fourteen-year-old boy, who was known to have hemophilia, was admitted for treatment of a deformity of the knee. He had injured the left knee during a strenuous pingpong game nine months before. Previously he had had frequent attacks of acute pain and swelling of the knees, ankles, and right elbow, but none so severe as that following the present injury. A flexion deformity had resulted. At another hospital a posterior cast had been applied, but when it had been removed the contracture had recurred and had become progressively worse.

Examination showed flexion contractures of 120 degrees in the left knee, 20 degrees in the right knee, and 40 degrees in each hip. The left knee was treated by manipulation and cast on three occasions, resulting in extension of the knee to only 15 degrees of flexion. He was discharged in three and one-half months, able to walk with brace and crutches.

At the time of his discharge, the left great toe was slightly swollen. This swelling gradually increased to the size of a golf ball, and then slowly subsided almost completely. Six weeks before re-entry, without antecedent trauma, the toe had begun to increase in size again, with discoloration of the surrounding tissue, and had become painful.

At the time of his second admission, ten months after his previous discharge, the left great toe had been almost completely replaced by a bluish-red, somewhat fluctuant mass, eleven centimeters by seven centimeters, which had displaced the terminal phalanx of the great toe forward, and had destroyed the entire proximal phalanx and a part of the metatarsal bone.

Possible diagnoses included hemophilic hemarthrosis, and malignant tumor of the great toe (synovioma or osteogenic sarcoma). An amputation was performed through the ankle joint after a series of transfusions had brought the blood-clotting time down to thirty minutes. There was no great bleeding.

The resected specimen showed a massive hemorrhage into the joint and surrounding tissues with varying degrees of organization, but no tumor. All the process was hemophilic.

For several days following the operation, the patient was mentally confused, which suggested a subarachnoid or cerebral bleeding, but as this cleared up spontaneously in about a week, no lumbar puncture was done. The boy was discharged from the Hospital.

MENINGOCOCCAL MENINGITIS WITH PURULENT ARTHRITIS. REPORT OF A CASE. James P. Cattell. *The New England Journal of Medicine*, CCXXIX, 49, July 8, 1943.

While joint symptoms are not uncommonly associated with meningococcal meningitis and meningococcaemia, meningococcal arthritis with purulent effusion is a rarity. The author presents such a case in which purulent arthritis developed after the institution of adequate sulfadiazine therapy.

The patient, a housewife, aged fifty-two years, was admitted two days after the onset of symptoms, complaining of mental confusion, joint pains, and rash.

On laboratory examination, the spinal fluid, blood, and throat cultures were found to contain Group 1 meningococci. Shortly after admission, she was given five grams of sulfadiazine by clysis, and an oral dose of one gram every four hours. Although the blood level of free sulfadiazine was 15.6 milligrams per 100 cubic centimeters of blood the morning following admission, the blood culture was still positive. However, it was negative on all subsequent occasions.

On the sixth day, both knees became hot, swollen, slightly red, and exquisitely tender. The next day turbid fluid, which clotted almost immediately, was aspirated from both knees. It contained 39,400 white cells per cubic millimeter, with 98 per cent. polymorphonuclear leukocytes; no organisms were seen in stained smears, and the fluid was sterile on culture. The joints showed much improvement between the eleventh and fourteenth days.

The joints of the upper extremities had been decreasingly painful on motion, but on the ninth day swelling, tenderness, and increased limitation of motion occurred in the left elbow. This joint was not tapped, and the reaction subsided concomitantly with that of the knees, though motion was limited for several days.

The patient was discharged on the twenty-ninth day. At the follow-up examination three weeks later, the patient was asymptomatic except for generalized weakness.

A review of the literature is included.

THE NUTRITIONAL BACKGROUND OF PATIENTS WITH RHEUMATOID ARTHRITIS. Theodore B. Bayles, Hope Richardson, and Francis C. Hall. *The New England Journal of Medicine*, CCXXIX, 319, August 19, 1943.

The authors have studied thirty-one patients at the Robert Breck Brigham Hospital, Boston, to discover whether diet is a determining factor in rheumatoid arthritis. They found that the dietary history of these patients before onset was not grossly different from that of a cross section of families in the North Atlantic States. However, over two-thirds of the patients fell short of the National Research Council's recommendation for calcium, thiamine and riboflavin; about half had an inadequate intake of vitamin C, and a small number were deficient in protein, iron, or vitamin A or its precursors, by the standards set by this Council.

While these facts seem to be significant, they are not when it is realized that the patients studied were living on an average, normal diet. What is to be noted is that excessive worry, overwork, and chronic fatigue preceded the onset of the disease in most

of these cases, and the attack therefore appeared to be hastened because an increased requirement was not satisfied, rather than because any real food deficiency existed. The authors feel that it is important to know the patient's dietary history before onset, together with the physical and nervous stresses the patient was under, for, although the diet may have been normal, it may have been insufficient for the abnormal requirements of the patient.

EPICONDYLITIS HUMERI. K. G. Hansson. *New York State Journal of Medicine*, XLIII, 29, January 1943.

Epicondylitis humeri is a clinical entity with marked pain and tenderness about the epicondyle of the humerus and inability to make a tight fist or raise any weight with the forearm in pronation. It is brought on by play or work which entails repeated pronation and supination of the forearm with the elbow extended, or repeated extension of the wrist.

Most of the muscles concerned with the epicondyle are of the quick-action type, with relatively short muscle belly and long slender tendon, and are very elastic. In supinating the forearm, the head of the radius acts as a fulcrum, with the short lever from the head of the radius to the epicondyle on one side, and the long lever from the head of the radius to the hand on the other side. The relation is about one to ten. The epicondyle is at a disadvantage.

Study of the muscles reveals that the flexors and adductors are developed to a greater power than the extensors and abductors. The muscles arising from the internal epicondyle are much stronger than those coming from the external epicondyle. Older muscles are less subject to pathological changes. When the extensors and supinators are called upon for sudden feats of strength, they give way.

By tilting the roentgen tube 45 degrees, the author was able to find a shadow over the epicondyle which suggested an avulsion in some cases.

The outstanding symptom in this condition is pain. The onset is gradual. Traumatic epicondylitis is characterized by pain over the lateral elbow when a tight fist is made, either sharp and lancinating or a dull ache. It comes when lifting is done with the forearm in pronation, and is usually absent with the forearm in supination. There is no pain on resting.

The pathology is probably a tear between the tendinous origin of the extensor carpi radialis brevis and the periosteum. A periostitis is produced with more or less myofasciitis and fibrositis in the muscle.

For treatment the author recommends immobilization by means of a cocked-up splint. This shortens the extensor muscles from the lateral epicondyle and prevents full pronation. Manipulation has little success in these cases. It is however the treatment of choice in traumatic epicondylitis, where there is a lack of complete extension in the elbow due to spasms of extensor muscles.—*H. de Goes, M.D., Iowa City, Iowa.*

CRUSH INJURIES AND THE CRUSH SYNDROME. W. H. Bueermann. *Northwest Medicine*, XLII, 109, April 1943.

The author reports the experience of English surgeons, who have found a striking syndrome in cases where limbs have been crushed under fallen debris for a period of from three to thirty-six hours. The syndrome is characteristic of shock accompanied by the signs of marked acidosis.

Amputation of the swollen and oedematous limb with poor circulation has provided no relief,—the cases ending fatally within seven to ten days. Intravenous fluids also have provided no relief, but have caused complete anuria in some instances. However, alkalinization has proved to be distinctly beneficial. Patey and Robertson have obtained excellent results with the administration of massive doses of blood plasma intravenously, together with milking the extravascular fluids back into the circulation by applying pneumatic-cuff pressure of fifty to sixty millimeters of mercury to the limb, intermittently, during waking hours.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

GOLD SALTS IN THE TREATMENT OF CHRONIC ARTHRITIS; METABOLIC AND CLINICAL STUDIES. R. H. Freyberg. *Proceedings of the Mayo Clinic*, XVII, 534, 1942.

This is a report of metabolic and clinical studies of gold-salt preparations used in the treatment of chronic arthritis. Various gold preparations were used, organic and inorganic, soluble and insoluble in water, in colloidal suspension, and in solution. The gold content varied from 37 per cent. to 87 per cent. The study showed that the effectiveness of the salts depended on the amount of gold in them.

The initial dose given varied from ten milligrams to fifteen milligrams, at weekly intervals, and was increased to twenty-five, fifty, and one hundred milligrams until one gram was reached. The plasma concentration as well as the excretion of gold in the urine and faeces were studied. The greatest amount of gold was found excreted in the urine the day of injection, indicating its rapid absorption. Twenty per cent. was excreted and 80 per cent. was retained.

The intramuscular injection of soluble crystalline salt sodium thiomalate (myochrysine), at weekly intervals, resulted in a step-like increase of gold concentration in the plasma. When the dose was kept constant, the plasma gold no longer increased, but remained relatively constant.

Similar results were found with gold sodium thiosulfate, where the rate of absorption was rapid. Gold thioglucose, prepared suspended in oil, showed increased absorption after constant doses. Calcium gold thiomalate (Sabin), an insoluble salt prepared in oil suspension for intramuscular injection, and the insoluble colloidal gold sulfide showed little or no gold in the plasma, only traces in the faeces, and none or traces in the urine. In the latter, this was found to be a result of phagocytosis by the reticular endothelium, especially in the spleen and the liver, and explains its less toxic effect and also its lack of therapeutic value.

The gold in the plasma and the gold secretion in the urine persisted for many months after the last injection was given, the urine often not becoming negative for eight to ten months.

The plan of treatment the author suggests is to inject myochrysine (50 per cent. gold) in amounts increasing from ten to fifty milligrams in weekly doses until one gram is given. Toxic reactions vary with individuals, and the administrator should gradually increase dosage accordingly.

The author found no effective means of avoiding the toxicity of gold therapy. Since gold therapy only lessens or arrests inflammation in arthritis, it should be used only in active rheumatoid arthritis.—*J. E. Kaufman, M.D., Iowa City, Iowa.*

FRATURA DA TUBEROSIDADE PÓSTERO-SUPERIOR DO CALCÁNEO—ESTUDO EXPERIMENTAL (Fracture of the Posterosuperior Tuberosity of the Calcaneum. Experimental Study). Edgar Rosa Ribeiro. *Revista Medica Municipal*, IV, 165, 1942.

The author asserts that fractures of this type are rare. Experimental studies on cadavera led to the understanding of the mechanism of this type of fracture which the author calls triangular fracture, or avulsion fracture of the Boyer type,—"a fall upon the point of the foot and dorsiflexion of the foot to an angle of less than 60 degrees will produce an avulsion of the posterosuperior tuberosity of the calcaneum by sudden and violent tension of the Achilles tendon and sural triceps which contracts in the attitude of defense". The author used open reduction, separation of the Achilles tendon from the os calcis, and mattress sutures uniting the fragment, Achilles tendon, and os calcis. This was followed by fixation in plaster for thirty days. The result was good.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

TRAUMATOLOGIA DESPORTIVA E CALCIFICAÇÕES METATRAUMÁTICAS PARATICULARES (Calcification in and around the Joints following Injury Resulting from Sports). A. Caio do Amaral. *Revista Medica Municipal*, V, 295, 1943.

The author believes that overactivity and frequent contusions and sprains in athletes predispose to what he calls "metatraumatic paraticular calcifications". The lesions

may appear in any joint most exposed to repeated injury, and are due, as Leriche has shown, to local reflex vasodilatation with local decalcification of the epiphyses and prominent bony parts, as well as to metabolic local changes. A few roentgenograms illustrate typical lesions involving the shoulder, elbow, wrist, knee, and ankle. The author believes that the treatment of these lesions by injections of novocain are not satisfactory, unless the injections are followed by physiotherapy and rest. Roentgenotherapy is the method of choice.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

AMPUTATIONS IN CHILDREN. Frederick vom Saal. *Surgery, Gynecology and Obstetrics*, LXXVI, 709, June 1943.

The author has studied the results of early amputation in twenty-three children and found that sixteen of twenty children had bone protrusion or painful long stumps with tightly stretched skin and soft parts.

Growth of the upper humeral, tibial and fibular epiphyses is rapid while growth of the soft parts at the stump end is not correspondingly so, due to muscle atrophy and diminished blood supply.

An "ideal" stump length may be obtained after the age of six years. The author advises epiphysiodesis, to be performed three weeks after primary amputation, or simultaneously with reamputation. In this way, continued growth of the epiphysis, with resultant bone protrusion, pain, stretched skin and soft parts, or an unwieldy stump, may be avoided. A prosthesis is easily fitted to the "ideal" stump.

INFILTRATION THERAPY OF ACUTE TENDINITIS WITH CALCIFICATION. Paul W. Lapidus. *Surgery, Gynecology and Obstetrics*, LXXVI, 715, June 1943.

In reviewing the literature on intratendinous calcareous deposits, the author states that little was accomplished until it was realized that the painful syndrome was caused by actual calcified deposits within the tendons and not by fracture, bursitis, or intra-articular fibrous ankylosis. Irrigation of the bursa and novocain injection were partially helpful, but attempts to aspirate the deposits were not too successful.

The author has found infiltration therapy to be most rewarding in acute calcareous tendinitis. The tender spot is infiltrated with ten to twenty cubic centimeters of a one-per-cent. novocain solution, followed by thirty to sixty or more cubic centimeters of warm normal saline solution. Roentgenograms are taken to ensure placement of the needle directly into the deposit. Although there is considerable pain for two or three days following the infiltration, exercise is encouraged. Mobility is gradually restored within two or three days to two weeks. Roentgenograms taken two or three days after the infiltration show fragmentation of the deposit. After three weeks, further spreading is observed, and two to four months later the deposit may have completely disappeared.

Tendinitis involves the shoulder more often than the elbow, hip, knee, foot, or wrist, because of its hypermobility and consequent susceptibility to strain and trauma.

IMMEDIATE ACTIVE MOTION TREATMENT OF FRACTURES OF THE HEAD AND NECK OF THE RADIUS. James A. Mason and Ned M. Shutkin. *Surgery, Gynecology and Obstetrics*, LXXVI, 731, June 1943.

The elbow is a bicondylar joint and smooth motion is dependent on synchronization of the two joints. Treatment of fractures of the head and neck of the radius by immobilization for three weeks, followed by physiotherapy, has secured poor functional results. The authors have successfully initiated immediate active motion after reduction of fractures of the head and neck of the radius, with 95 to 100 percentage of function obtained. No fixation of the elbow is used, other than a simple arm sling, holding the elbow at a right angle. Continuous hot packs are applied to treat soft tissue injury and to overcome muscle spasm. Movement of the elbow is guided by the physician with the active cooperation of the patient. This motion, begun before the fragments have

become fixed, allows them to be moved across the fixed, uninjured articular surfaces of the humerus, thus attaining the best functional position in relation to the joint surfaces.

With less than a year's observation of results, it is impossible to exclude subsequent development of posttraumatic arthritis in the cases under the active motion regimen.

THE EVOLUTION OF THE CIRCULATION IN THE DEVELOPING FEMORAL HEAD AND NECK. AN ANATOMIC STUDY. W. Eugene Wolcott. *Surgery, Gynecology and Obstetrics*, LXXVII, 61, July 1943.

The author has attempted to clarify the controversial subject of circulation in the developing head of the femur. He has exhausted the literature and has pointed out the two schools of thought:

1. That the ligamentum teres is the most important source of blood;
2. That the visceral capsular arteries are the main supply of blood.

He then added his own experience in experimental work, and came to the conclusion that, in infants and children, the ligamentum teres vessels form an insignificant source of blood, as compared to the visceral capsular vessels which arise from the median circumflex artery. He further concluded that about the time when ossification of the head is completed, anastomosis occurs between the ligamentum teres vessels and vessels from the visceral capsule. He suggested that this knowledge might prove to be helpful in many approaches to a better understanding of such hip conditions as Legg-Perthes disease and slipped epiphysis.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

HERNIATION OF THE NUCLEUS PULPOSUS. AS A COMPLICATION OF PRE-EXISTING LOW BACK INSTABILITY. Edwin M. Deery. *Surgery, Gynecology and Obstetrics*, LXXVII, 79, July 1943.

In a rather long discussion, the author points out that cases of herniated nucleus pulposus fall generally into two groups from the standpoint of treatment:

1. Those in which patients give a fairly routine history of most of the pain being sciatic, with a minimum of low-back pain, and no outstanding preceding history of back trouble;
2. Those in which a herniated nucleus pulposus is a complication of low-back instability.

He is particularly interested in discussing Group 2, and makes a strong suggestion that in this group of patients the cooperative assistance of the neurosurgeon and orthopaedic surgeon is necessary. It is this group of patients who are not completely relieved by simply removing the disc, but who also need a spine fusion. In many instances the need for spine fusion can be decided preoperatively, thereby allowing both to be accomplished at one operation.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

POSTERIOR HORN LESIONS IN MENISCAL INJURY. Donald B. Slocum and Donald E. Moore. *Surgery, Gynecology and Obstetrics*, LXXVII, 87, July 1943.

As a result of studies of 110 patients operated upon at the Letterman General Hospital from January 1941 to November 1942, the authors emphasize the importance of adequate treatment of lesions in the posterior part of the meniscus. In eighty-one cases, resection of the entire meniscus was done. The persistence of tears, tabs, or other incongruities results in residual symptoms of meniscus injury, and for this reason the cases have been divided into four groups.

Group 1. Total excision of the meniscus is mandatory in the presence of the following conditions:

(a) Posterior bucket-handle tear;
(b) Avulsion of the posterior third;
(c) Posterior angle tears;
(d) Complete avulsion of the meniscus except at the anterior and posterior attachments;
(e) Bucket-handle tears with separation in the mid-portion;

(f) Separate tears of both anterior and posterior horns;
(g) Excision of the posterior third of the meniscus;
(h) Cysts of the lateral meniscus.

Group 2. Total excision of the meniscus should usually be done in the presence of:
(a) Bucket-handle tears;
(b) Tears of the middle one-third;
(c) Hypermobile menisci.

Group 3. Total excision is controversial in the case of lesions limited to the anterior half of the meniscus. In the light of the authors' experiences, complete removal of the meniscus in all cases was necessary because visualization was not always reliable in ruling out posterior-horn lesions.

Group 4. When no pathological lesion is visualized, it is better to excise the meniscus on the basis of symptoms alone. The posterior-click test was put forth as a valuable agent in the diagnosis of posterior-horn lesions which were found to exist in 21 per cent. of the cases.

The authors found the short anteromedial or anterolateral incision the approach of choice. An additional exposure through the Henderson approach or the use of a tenotome could be applied to free the posterior elements in cases where the knee was tight.

They concluded that the presence of a posterior click is indicative of posterior-horn pathology, but absence of the sign does not rule out a lesion. In all cases of exploratory arthrotomy, the entire cartilage should routinely be removed.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

PROBLEM OF HERNIATED NUCLEUS PULPOSUS IN THE MILITARY SERVICE. Walter G. Haynes. *War Medicine*, III, 585, 1943.

The author studied twenty-one cases of herniated nucleus pulposus seen at the Lovell General Hospital, Camp Devens. Eleven patients were discharged because of disability arising from a condition which had existed prior to induction, and ten were operated upon. The author believes that with the proper selection of patients, 90 per cent. can be returned to duty following surgery.

The most constant signs and symptoms are pain in the back or legs—usually in both—following the distribution of the sciatic nerve, which usually develops after a minimal amount of trauma and is made worse by coughing or sneezing; tenderness of the spinous process over the suspected disc; positive Lasègue's sign; and a diminished or absent Achilles-tendon reflex. Anaesthesia is valuable if present, but not significant if absent. Spinal-fluid protein is significant if increased, but a normal value is not, in itself, evidence against the presence of a protruded disc. He found that flat roentgenograms were of no value, and myelography was often misleading. Radiopaque oil was not used. For the operation to be successful in returning the patient to duty, the patient must be psychiatrically sound, and have no stigmata of psychoneurosis.

The author emphasizes certain minor points of surgical technique. The patient's hips are raised so that the lumbar curve is obliterated and the disc is forced posteriorly. The anaesthetic is usually 1-per-cent. procaine hydrochloride, infiltrated along the line of incision and into the paravertebral muscles. As little bone as possible is removed, so as not to weaken the back.

Postoperative care is important. The patient is kept in bed fourteen days, and then is provided with a tight well-fitting lumbosacral belt before he is allowed up. After approximately one week about the ward, he is given a thirty-day furlough, during which time he continues to wear the belt and gradually resumes his usual activity. On his return, he is given ten days to two weeks of extensive physical therapy, including exercises to strengthen the back muscles and to increase the degree of body flexion.

The average time required for preliminary studies, operation, and convalescence is approximately eight weeks. Of the ten patients operated upon, nine were returned to full duty, and one was discharged from the Army because of psychoneurosis.

In borderline cases surgical treatment is withheld except as a last resort.

ACKNOWLEDGMENTS

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

América Clínica (New York, N. Y.), V, Núm. 5, 1943.

Anais Paulistas de Medicina e Cirurgia (São Paulo, Brasil), XLIV, No. 6 e Indice, 1942; XLV, Nos. 1, 3, e 4, 1943.

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